

Tuning Pbar Kicker Timing While Stacking



Last Modified: 10/31/2005 10:09:51 by Brian Drendel

Created: 10-14-05 by Brian Drendel

Send comments and suggestions to the [Pbar Tuning Guide Admins](#)

Draft Release 0.26

Introduction:

This document is divided into multiple sections. Click on the section title to go directly to the corresponding section.

1. [Introduction](#): The introduction outlines all of the sections contained in this document and provides quick links that allow the reader to go directly to any section.
2. [Revision History](#): The revision history lists the dates and changes made in each major revision of this document.
3. [Prerequisites](#): This is a list of what items need to be tuned before you can complete this procedure.
4. [Background](#): The background section explains why we need to align the kicker timing.
5. [Setup](#): This section outlines what setup is required prior to starting this procedure.
6. [Full Length Procedure](#): This is the full length version of the procedure, complete with screen captures and detailed discussion.

7. [Condensed Procedure](#): This is a condensed version of the procedure without any screen captures, nor discussion.
 8. [Printable Version](#): The HTML version of this document is optimized for viewing. Go to the printable version for a PDF file optimized for printing.
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Revision History:

Before completing this tuning procedure, make sure that you have already verified that the following tuning has been completed:

1. Draft Release v0.10: 10-14-05 by Brian Drendel. Wrote condensed procedure outline and added first round of screen captures.
 2. Draft Release v0.20: 10-20-05 by Brian Drendel. Split up the condensed procedure into ops and experts sections. Added figure tables to screen captures.
 3. Draft Release v0.21: 10-24-05 by Brian Drendel. Wrote prerequisites and worked on full length procedure.
 4. Draft Release v0.22: 10-26-05 by Brian Drendel. Started to outline information for background section.
 5. Draft Release v0.23: 10-27-05 by Brian Drendel. Further developed the background section. Added the scope traces.
 6. Draft Release v0.24: 10-28-05 by Brian Drendel. Broke the background section into three sub-sections. Completed background section. Inserted figure numbers and bookmarks to figures. Wrote full length procedure text.
 7. Draft Release v0.25: 10-28-05 by Brian Drendel. Entered in Documents Database [Document 2009](#).
 8. Draft Release v0.26: 10-31-05 by Brian Drendel. Added/improved text in figure headings.
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Prerequisites:

Before completing this tuning procedure, make sure that you have already verified that the following tuning has been completed:

1. Before a Debuncher Injection Kicker timing tune-up:

- ✱ Check the Pbar Proton Torpedo from P194 to verify that 81 bunches are detected that are both even in intensity and bunch length. If not, refer to the Main Injector and Booster tune-up procedures.

- ✱ Target Tune

2. Before a Debuncher Extraction and Accumulator Injection Kicker timing tune-up:

- ✱ Contact an Pbar expert as this is an expert-only procedure.

Background:

The purpose of this document is to outline the Pbar kicker alignment procedure. The background section of this procedure explains why we need to align the kicker timing, and is broken into three sections. Click on a link below to go directly to that section, or scroll down to review the entire document.

- ✱ Background Part 1: [Bunch Evolution of Protons on Target](#)

- ✱ Background Part 2: [Debuncher Injection Kicker Timing](#)

- ✱ Background Part 3: [Debuncher Extraction and Accumulator Injection Kicker Timing](#)

Background: Part 1: Bunch Evolution of Protons on Target

A Booster batch consists of 84 bunches of 53MHz beam. The Booster Notcher removes three of those bunches, leaving 81 bunches. The Booster batch is extracted down the MI8 line, where the 8 GeV wall current monitor can detect the individual bunches in the batch. The MI8 proton torpedo (see [Figure 1](#)) displays information on the intensity and bunch length of each of the 81 bunches. This display can be used to verify that Booster is sending the correct number of bunches to the Main Injector.

{Insert Picture of 8 GeV Proton Torpedo here}

Figure 1: The MI8 Proton Torpedo. 81 bunches of beam should be extracted in each Booster batch.

Two consecutive 8 GeV 81 bunch Booster batches are injected into the Main Injector and slip-stacked into one 8 GeV 81 bunch batch. The beam is then accelerated to 120GeV in the Main Injector and sent through the P150, P1, P2, and AP1 lines on its way to the Pbar Target. The AP1 wall current monitor can detect the individual bunches in the batch. The Pbar Proton Torpedo (see [Figure 2](#)) displays information on the intensity and bunch length of each of the 81 bunches. This display can be used to verify that the Main Injector is sending the correct number of bunches to the AP1 line.

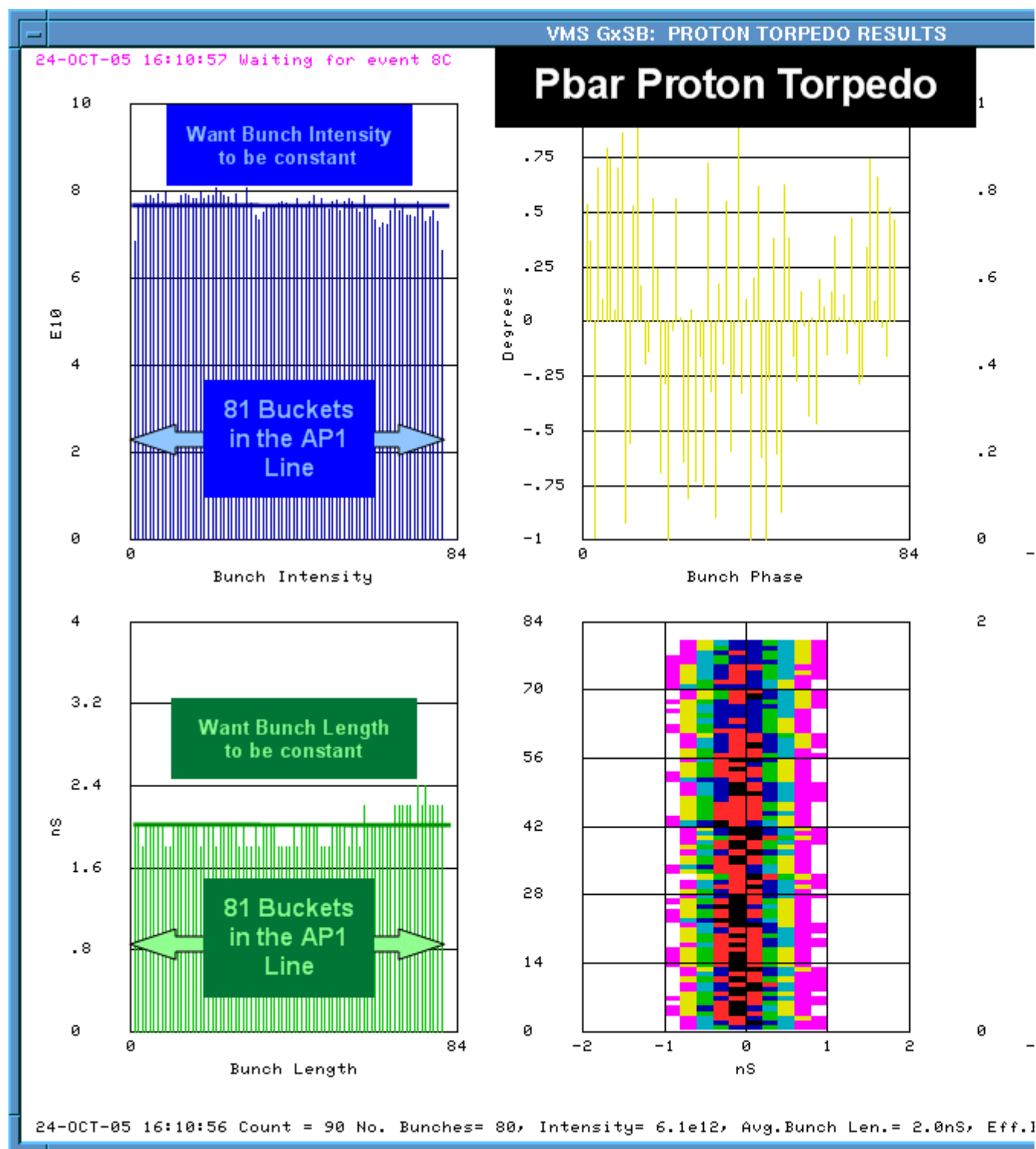


Figure 2: The Pbar Proton Torpedo display uses the wall current monitor in the AP1 line. The display gives us an indication of the structure of the beam on target. We should see 81 bunches that are evenly distributed in intensity and bunch length.

The 120 GeV protons then strike the Pbar target. We collect the negatively charged 8 GeV Pbars plus other particles coming off the target and send them down the AP2 line. The resulting beam has the same bunch structure as the beam on target, so we would expect this beam to contain a string of 81 bunches. We inject the 81 bunches of beam from the AP2 line into the Debuncher using a septum/kicker combination. The septum magnet has two apertures, one for the incoming AP2 beam and one for the circulating Debuncher beam. The septum magnet bends the incoming beam parallel to the circulating Debuncher beam such that the Debuncher injection kicker can kick the incoming beam on the Debuncher closed orbit. Since circulating and incoming beam are in the same aperture at the location of the Debuncher injection kicker, the time that the kickers fire is crucial.

Background: Part 2: Debuncher Injection Kicker Timing

Debuncher Injection Kicker, shown in [Figure 3](#), is single-turn transmission line pulsed magnet consisting of three meter long modules. Each module has its own trigger circuitry that tells the kicker when to fire, and its own pulsed forming network that determines the shape and duration of the kicker pulse.

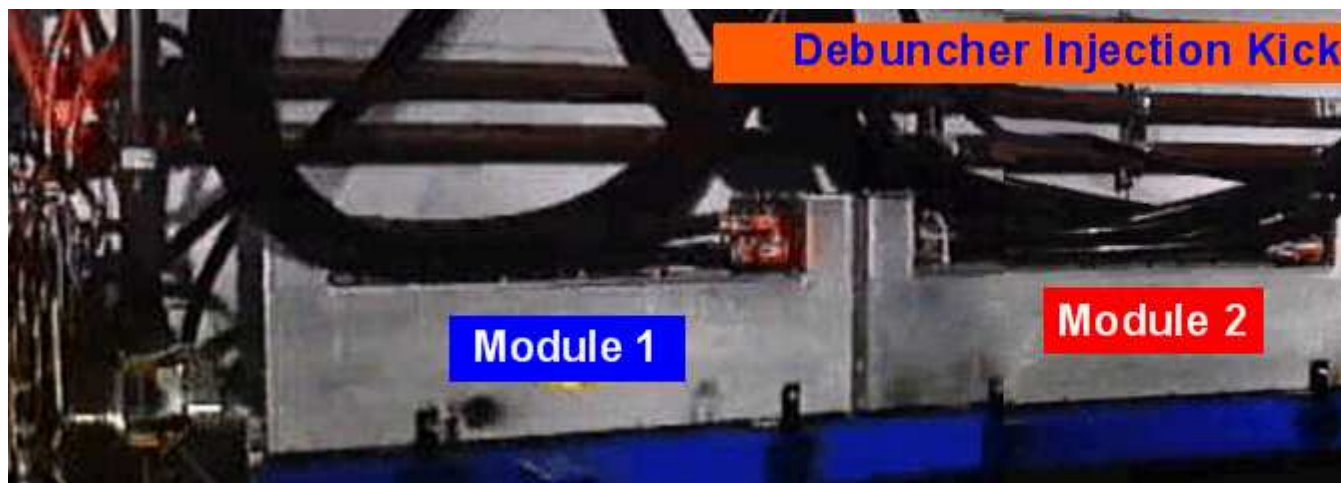


Figure 3: The Debuncher Injection Kicker is a single-turn transmission line pulsed magnet consisting of three meter long modules. Each module has its own trigger circuitry that tells the kicker when to fire, and its own pulsed forming network that determines the shape and duration of the kicker pulse.

There is an oscilloscope setup that watches the relative timing between the three kicker modules. This scope can be viewed via a web browser at the address <http://deb-ikik-scope.fnal.gov/>. If the kicker modules are timed relative to each other, then the peaks of the traces will line up as shown in [Figure 4](#).

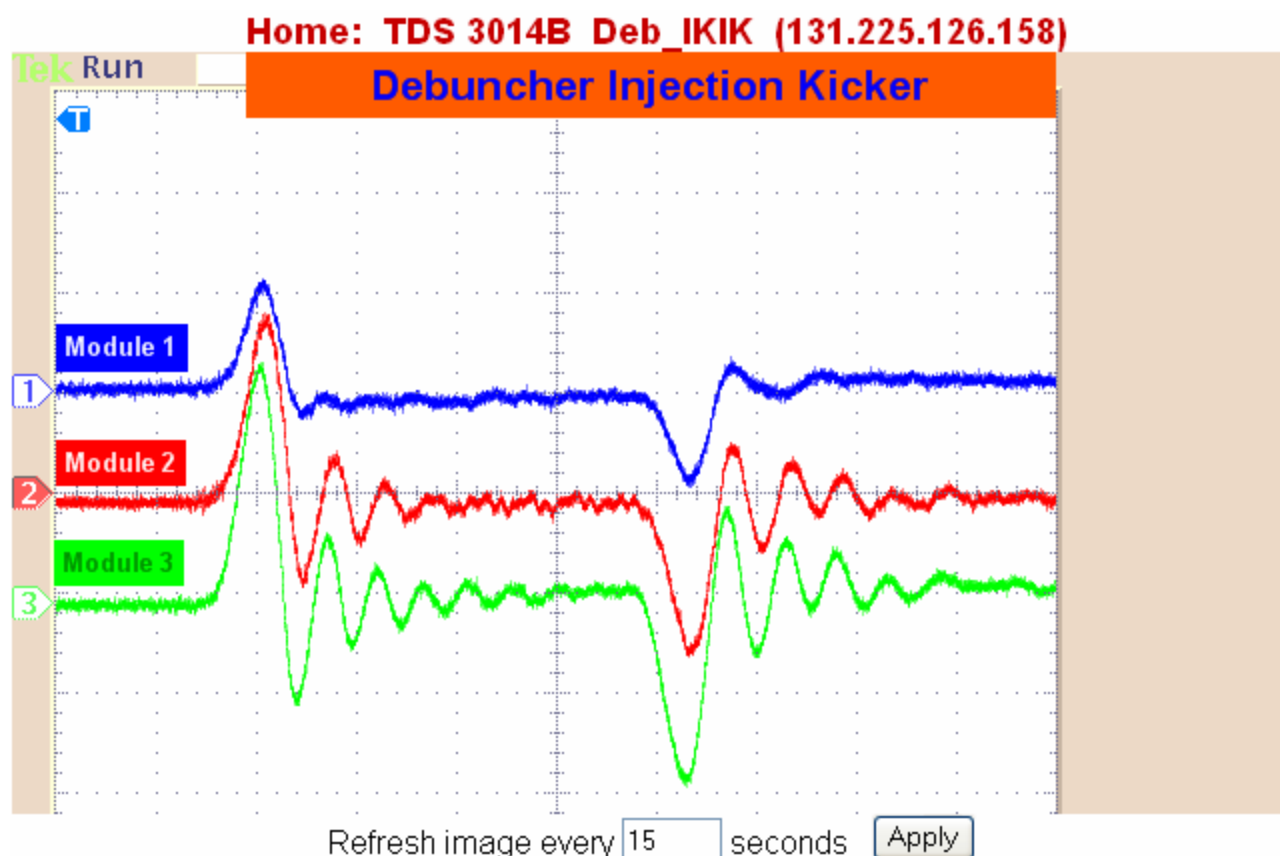


Figure 4: The Debuncher Injection kicker scope. If the kicker modules are timed correctly with respect to each other, the peaks on the left portion of the trace will be aligned. We can see in this screen capture a slight misalignment of module 2.

It is very important that the timing of these modules is set precisely. Each kicker module must be at full current when the beam from AP2 arrives so that the magnetic field from the kicker can put the injected beam on the Debuncher closed orbit. Likewise, once the injected beam has circulated around the Debuncher and is again at the kicker location, each kicker module must be at zero current so that the kicker does not disturb the circulating Debuncher beam. If the kickers are ramping up or down while beam is going by, that beam will be lost. To make a hole for the kickers to fire, DRF2 maintains a 200nsec gap in the Debuncher beam. When timed properly, the barrier bucket gap passes over the Debuncher injection kickers during the time that the kickers fire, minimizing beam loss due to the firing of the kicker.

How can we tell if our kickers are firing at the correct time in relation to our gap? The Flux Capacitor Scope connects to Debuncher gap monitor to collect information about the beam injected into the Debuncher. This scope can be viewed either from CATV Pbar #18 or online at <http://ap10-flux-scope.fnal.gov/> as shown in Figure 5. The scope shows the DRF2 waveform and the 81 buckets after they have been

injected into the Debuncher. The display of 81 buckets should have the same structure as the 81 buckets viewed with the Proton Torpedo displays (see [Figure 1](#) and [Figure 2](#)). If the Proton Torpedo shows that there are 81 buckets on target, but the Flux Capacitor shows reduced intensity or missing bunches on either the front or back end of the beam distribution, then we may suspect a kicker timing issue. Sometimes this is hard to see by eye, so tools have been developed to quantify this information.

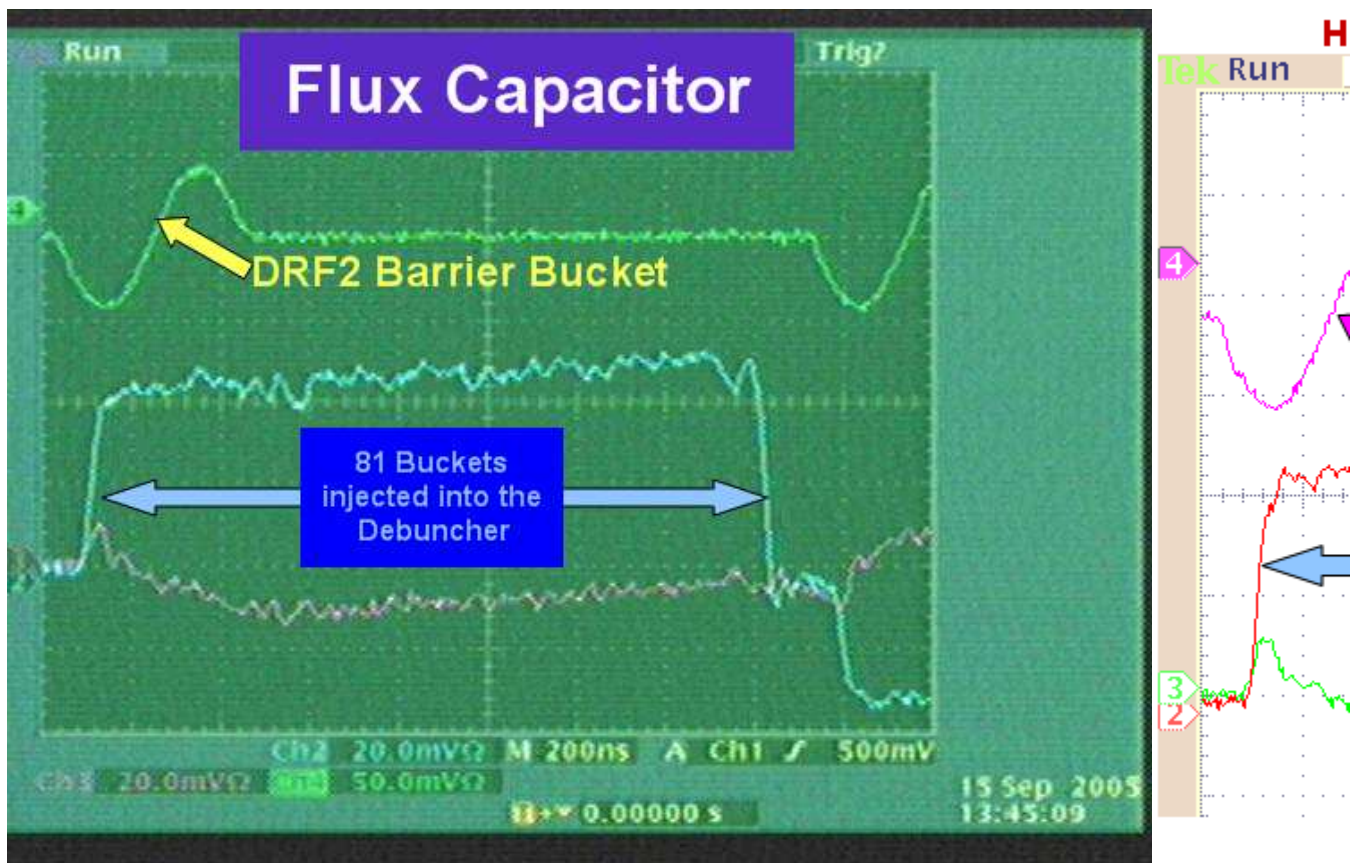


Figure 5: The flux capacitor scope is used to indication how much beam is being injected into the Debuncher. The scope can be displayed either from CATV Pbar #18 (plot on the left) or online at <http://ap10-flux-scope.fnal.gov/> (plot on the right). The Cyan trace on the CATV screen shows the bunches injected first turn in the Debuncher. The height of the trace is an indication of intensity and the width of the trace is an indication of how many consecutive bunches are injected. Ideally, we would like to see a square wave of 81 consecutive bunches.

Paul Derwent constructed an OAC that examines the Flux capacitor display ([Figure 5](#)) and outputs ACNET parameters. D:FLXBTL is the length in μsec of the injected beam, D:FLXBBK is the equivalent number of buckets in that injected beam, and

D:FLXGBK is the number of buckets in the gap. A couple of simple calculations can show us the ideal values for the above parameters. The Debuncher has a 53MHz harmonic number of 90 buckets. It takes beam 1.695 μ sec to complete one revolution, so the transit time per bucket is about 0.019 μ sec. We know that the incoming 53MHz structured beam from AP2 should be 81 bunches long. That means that we will be filling 81 of the available 90 buckets in the Debuncher, and those 81 buckets would have a transit time of 1.5255 μ sec. That leaves a 9 bucket gap in the beam, whose transit time would be 0.1695 μ sec. If our kicker timing is optimized we should see 81 buckets in the beam train and a gap of 9 buckets. So the ideal values for the OAC generated parameters are D:FLXBTL = 1.5255 μ sec (smaller is worse), D:FLXBBK = 81 buckets (smaller is worse), and D:FLXGBK = 9 buckets (larger is worse). We can examine the above parameters to determine if the kicker timing is optimized. If not there are ACNET parameters that allow us to adjust the firing times of each kicker module (D:IKIKM1, D:IKIKM2, D:IKIKM3).

We now have all of the information needed to understand what we need to tune. Our goal in tuning the Debuncher Injection kicker timing is two-fold :

1. Align the three kicker modules to fire synchronously by lining up the three traces from the kicker scope ([Figure 4](#))
2. Have the kicker firing time centered on the DRF2 gap by maximizing D:FLXBTL or D:FLXBBK from the Flux Capacitor ([Figure 5](#)).

A Java application has been developed to do all of this work for us. The use of this application is the topic of the written procedure below.

Background: Part 3: Debuncher Extraction and Accumulator Injection Kicker Timing

Beam only stays in the Debuncher until shortly before the next stacking cycle. Afterwards, beam is extracted to the D/A line and then injected into the Accumulator. Both transfers involve kickers, whose timing modules we can tune. The timing of the modules in each of the kickers as well as the relative timing of the two kickers is important to optimize the transfer of the Debuncher beam to the Accumulator.

The beam is Debunched in the Debuncher, so we have lost our 81 bucket structure; however, we still have the 200nsec gap in the beam preserved by DRF2. The beam is cooled and circulates on the order of a few seconds before it is kicked off of the closed Debuncher orbit with the Debuncher extraction kicker. The kicked beam

goes through the field aperture of the Debuncher Extraction septum and on to the D/A line. This Debuncher extraction kicker must have its rise time inside of the DRF2 gap in order to most effectively extract the beam. Like the Debuncher Injection Kicker, the Debuncher Extraction Kicker (see [Figure 6](#)) consists of three separate modules. Each module has its own trigger circuitry that tells the kicker when to fire, and its own pulsed forming network that determines the shape and duration of the kicker pulse.

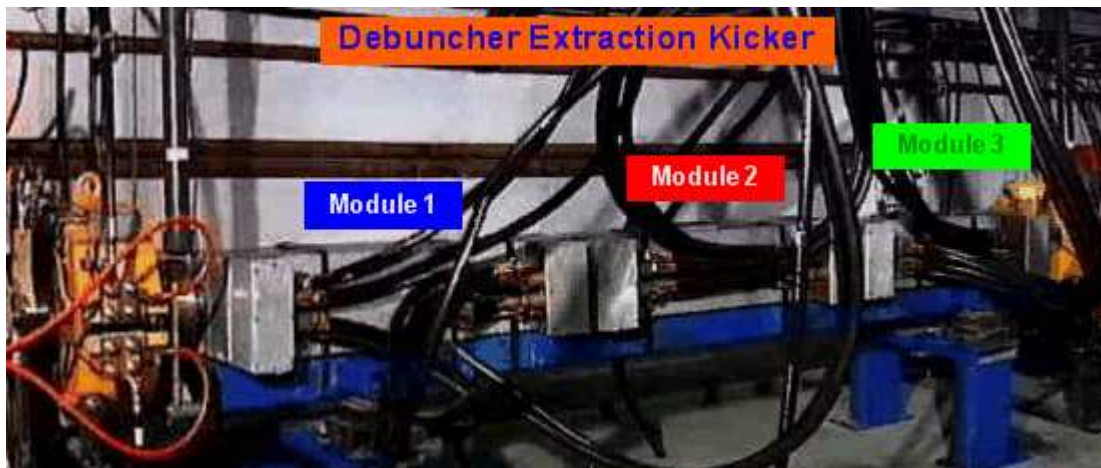


Figure 6: Debuncher Extraction Kicker is a single-turn transmission line pulsed magnet consisting of three meter long modules. Each module has its own trigger circuitry that tells the kicker when to fire, and its own pulsed forming network that determines the shape and duration of the kicker pulse.

There is an oscilloscope setup that watches the relative timing between the three kicker modules. This scope can be viewed via a web browser at the address <http://deb-ekik-scope.fnal.gov/>. If the kicker modules are timed relative to each other, then the peaks of the traces will line up as shown in [Figure 7](#).

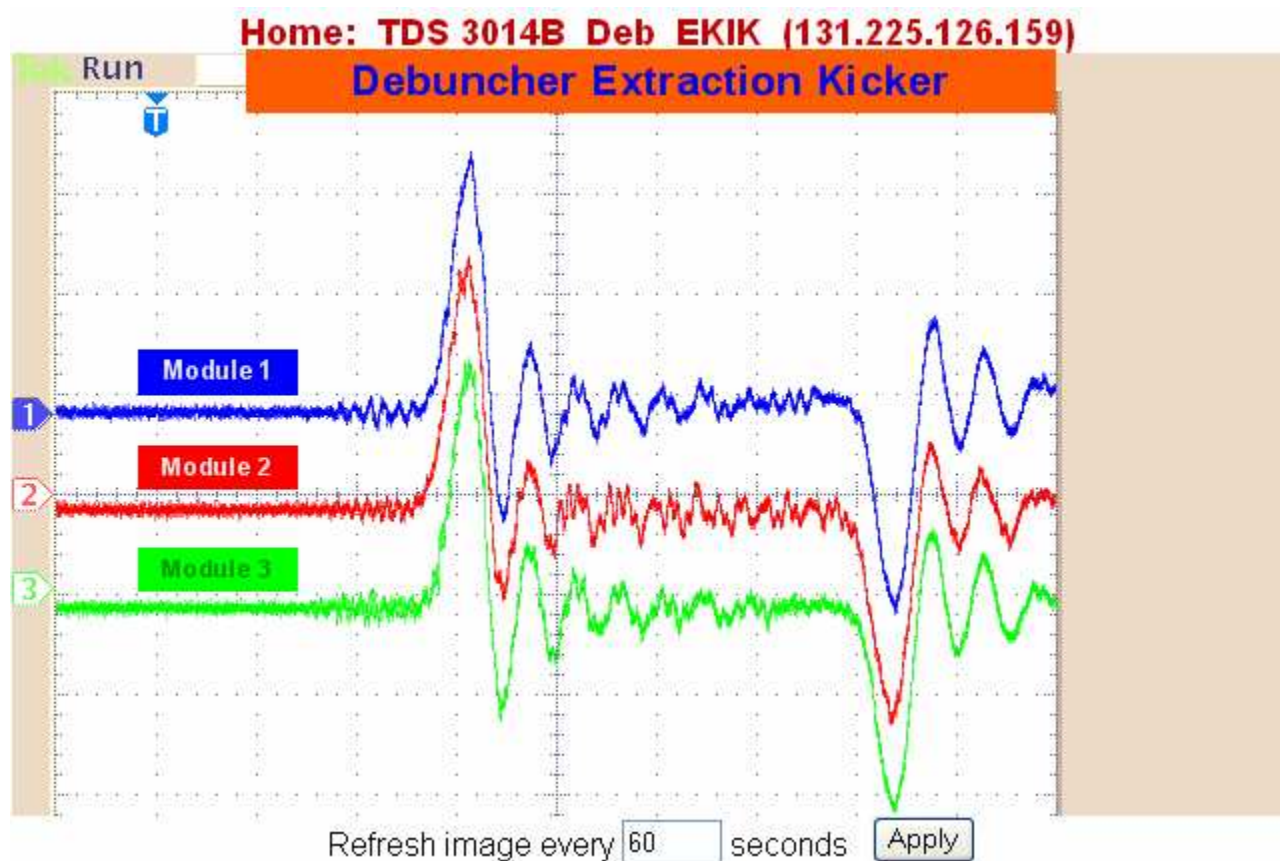


Figure 7: Debuncher Extraction Kicker Scope traces.

Unlike the Debuncher Injection Kicker, we do not have good diagnostics to show us where the kickers fire in relation to the DRF2 gap in the beam. The java application covered in this procedure can be used line up the individual modules with respect to each other, but has no way to align them with the gap. The best way we have to align this kicker with the gap is to carefully change a MULT:3 of D:EKIKM1, D:EKIKM2, and D:EKIKM3 while watching beam in the Accumulator. This type of tuning is usually left for Pbar experts only.

Beam from the D/A line passes through two Accumulator Injection Septum magnets that put in the incoming D/A beam parallel to the circulating Accumulator beam. The injected beam is kicked onto the Accumulator injection orbit using the Accumulator Injection Kicker (see [Figure 8](#)). The injection orbit is physically separate from the circulating core, and there is also no gap in the circulating core beam. As a result, the Accumulator Injection Kickers have an Aluminum plate, called the shutter, that drops between the injection orbit and core beam when the kickers fire. This shields the circulating core beam from the kicker pulse. As a result of having to engineer a shutter into the kicker design, the three kicker modules and shutter are all enclosed in one large tank.

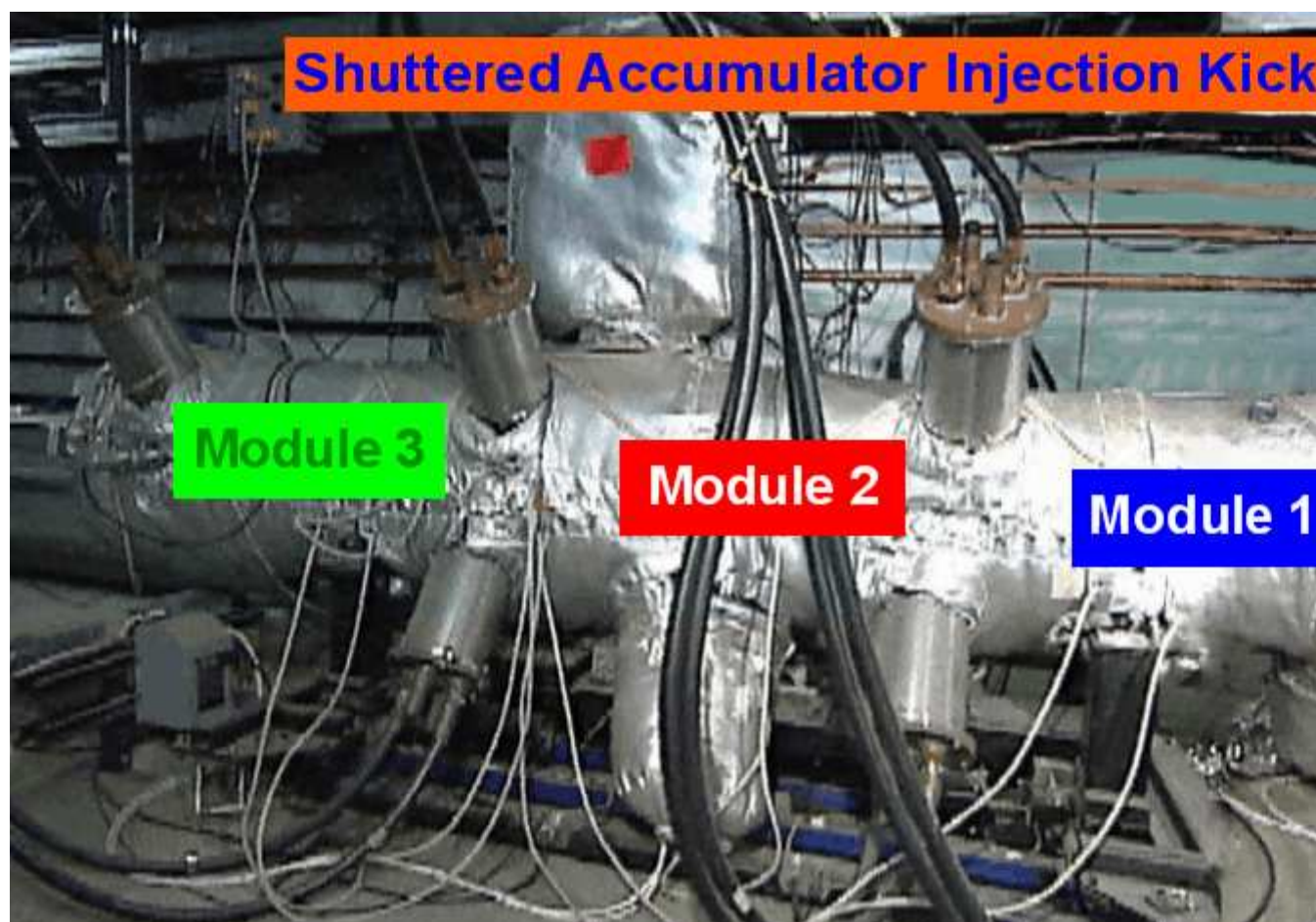


Figure 8: Accumulator Injection Kicker has three modules and a shutter that are internal to the kicker tank.

There is an oscilloscope setup that watches the relative timing between the three kicker modules. This scope can be viewed via a web browser at the address <http://acc-ikik-scope.fnal.gov/>. If the kicker modules are timed relative to each other, then the waveforms will line up as shown in [Figure 9](#).

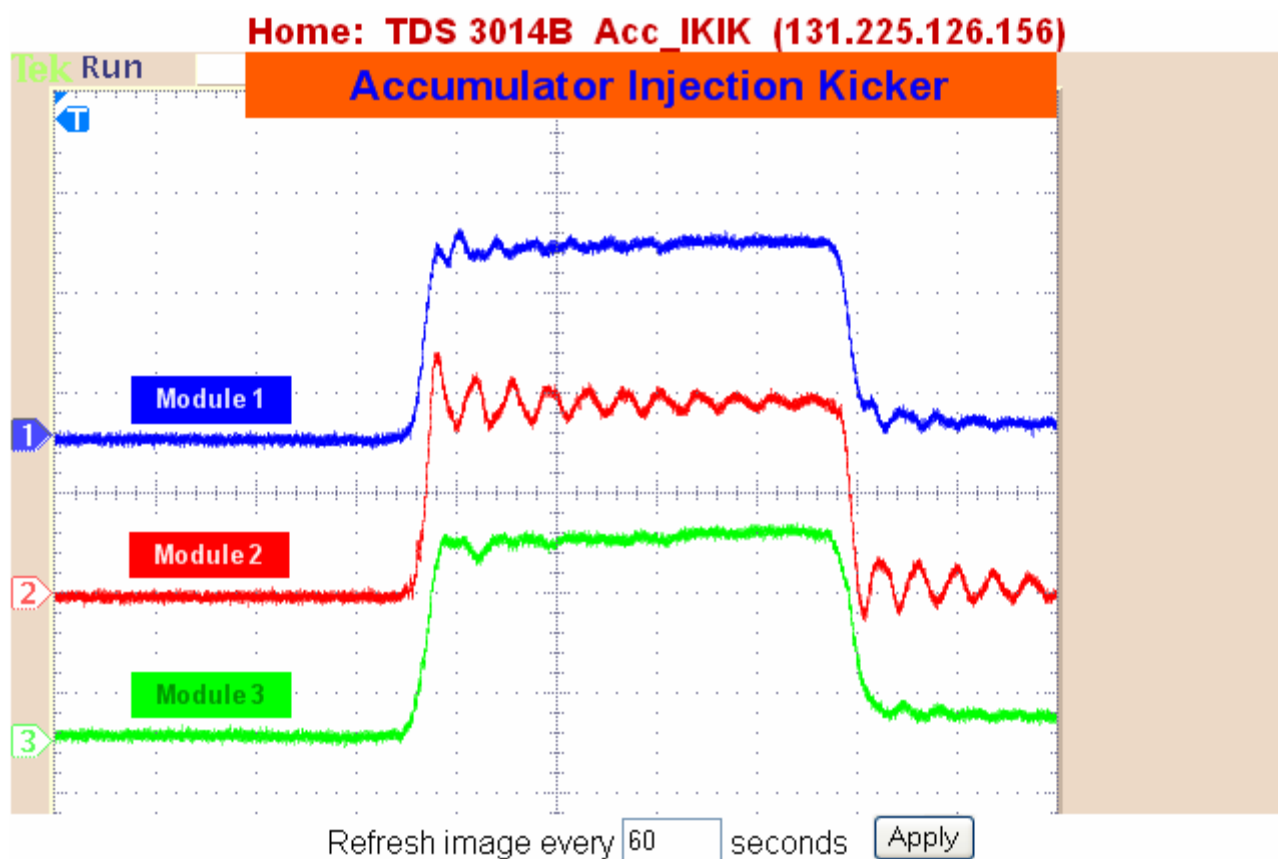


Figure 9: Accumulator Injection kicker scope.

We do not have good diagnostics to show that the Accumulator Injection Kicker timing is aligned with the incoming D/A line beam. The java application covered in this procedure can be used line up the individual modules with respect to each other, but has no way to align them with the beam. The best way we have to align the Debuncher Extraction kicker to the Accumulator Injection kicker is to carefully change a MULT of A:IKIKM1, A:IKIKM2, and A:IKIKM3 and watch beam in the Accumulator. We also can carefully change a MULT of A:IKIKM1, A:IKIKM2, A:IKIKM3, D:EIKIM1, D:EIKIM2, and D:EIKIM3 and watch beam in the Accumulator to align the Debuncher Extraction Kicker and Accumulator Injection Kicker times with the DRF2 gap. This type of tuning is usually left for Pbar experts only.

Setup

You will need to start the Java Kicker Timing Application. Details are given in the full length procedure below.

Full Length Procedure - Introduction

The following steps should be completed to align the Pbar kicker timing while stacking. This section contains screen captures and detailed discussion. If you are already familiar with this procedure and would prefer to review a [condensed version](#) of this procedure, then click [here](#). The procedure is broken into the following parts. Click on the link to go directly to that part of the procedure, or scroll down to view the entire procedure.

- a. **Part 1: [Start the Java Kicker Timing Application](#) (Ops or Pbar Experts)**
- b. **Part 2: [D:IKIK timer tuning](#) (Ops or Pbar Experts)**
- c. **Part 3: [D:EKIK & A:IKIK timer tuning](#) (Pbar Experts only)**

This document is under construction...only the [condensed version](#) of this procedure is currently available.

Full Length Procedure - Part 1: Starting the Java Kicker Timing Application

1. The Pbar Kicker Timing Java application (See [Figure 10](#)) can be started by clicking on the following link: <http://www-bd.fnal.gov/appix/start?p=40000142&n=35000508>. The application can also be started from the [Java Index](#). Click on "Launch in Application Browser." The Application Index window appears. Open the P * Pbar folder and double click on "Pbar Kicker Timing."

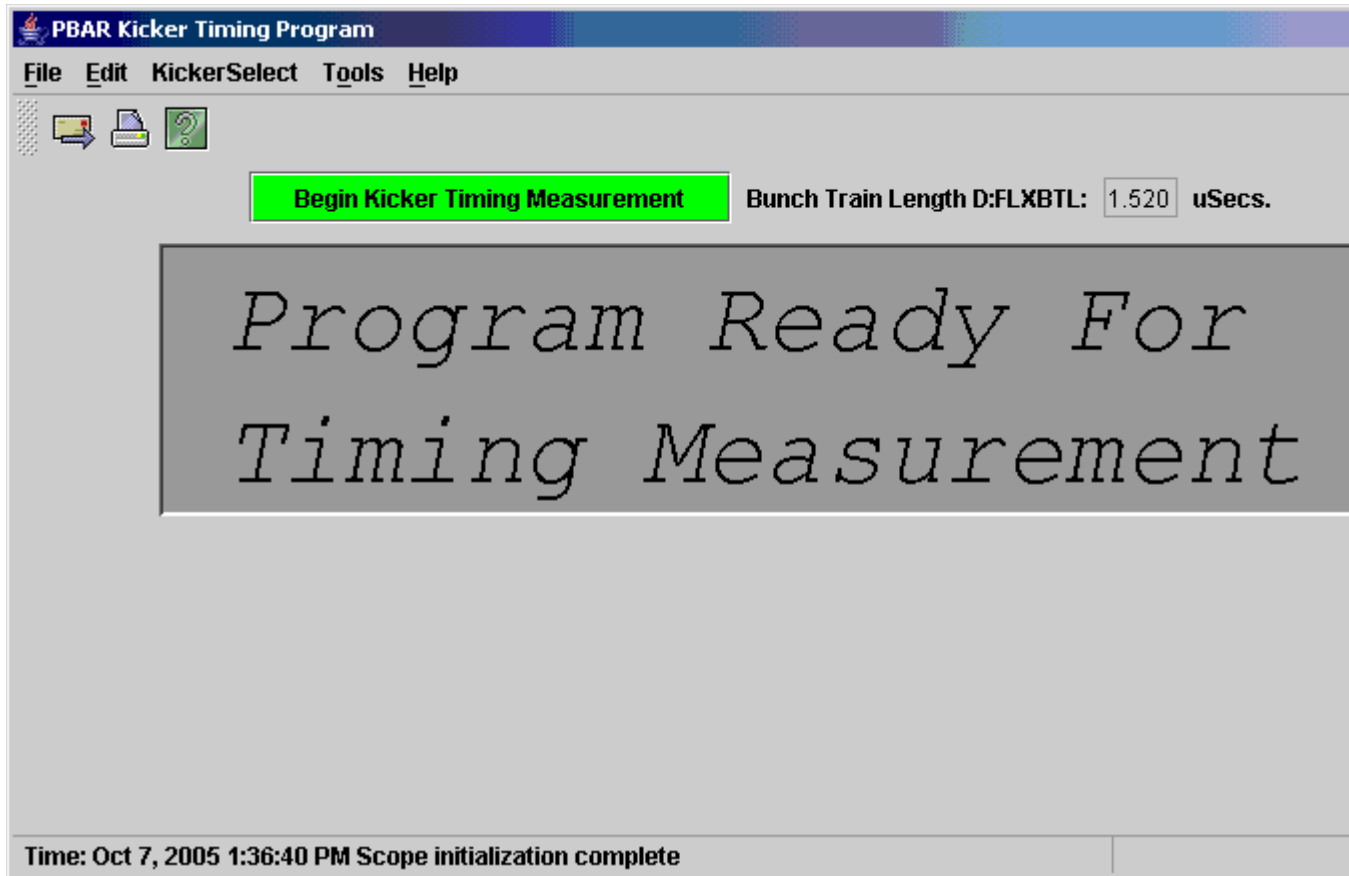


Figure 10: Java Pbar Kicker Timing Application.

Full Length Procedure - Part 2: Debuncher Injection Kicker Tuning ([Ops or Pbar Experts](#)).

This portion of the procedure will cover tuning the Debuncher Injection Kicker timing. We assume that the Java Kicker Timing application has been started as shown in [Part 1 of this procedure](#).

1. As shown in [Figure 11](#), start a FTP from Utility Window FTP Pbar File 87.

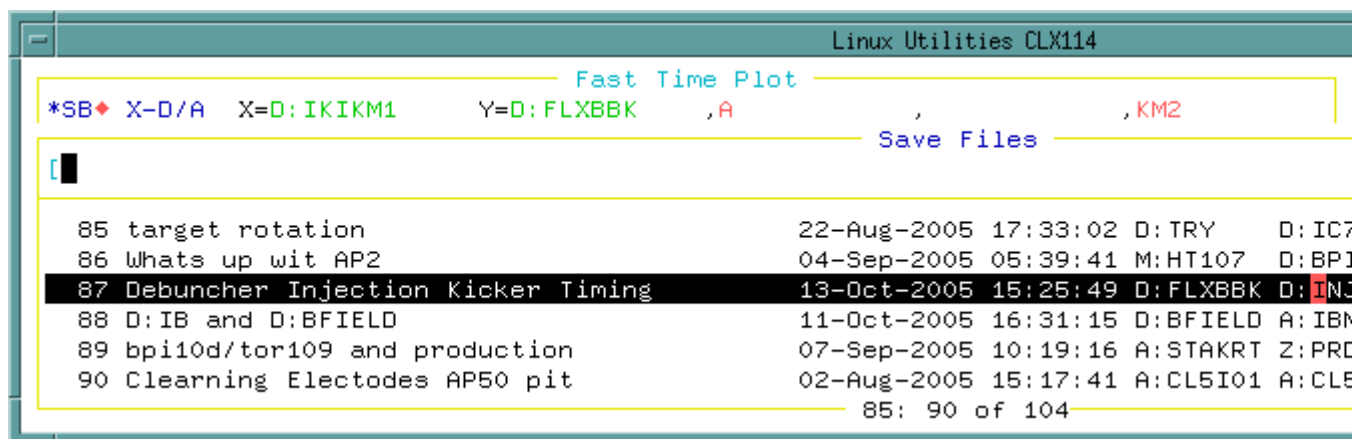


Figure 11 From the Utilities Window, click on FTP, then click on Restore, and then select P-bar. Select file 87 and start the FTP.

2. Pbar FTP #87 (shown in [Figure 12](#)) will show how our tuning efforts impact the number of bunches injected into the Debuncher (D:FLXBBK), the calculated Debuncher injection flux (D:INJFLX), the circulating Debuncher beam normalized to beam on target (D:BPI10D/M:TOR109). Larger numbers are better for all three traces.

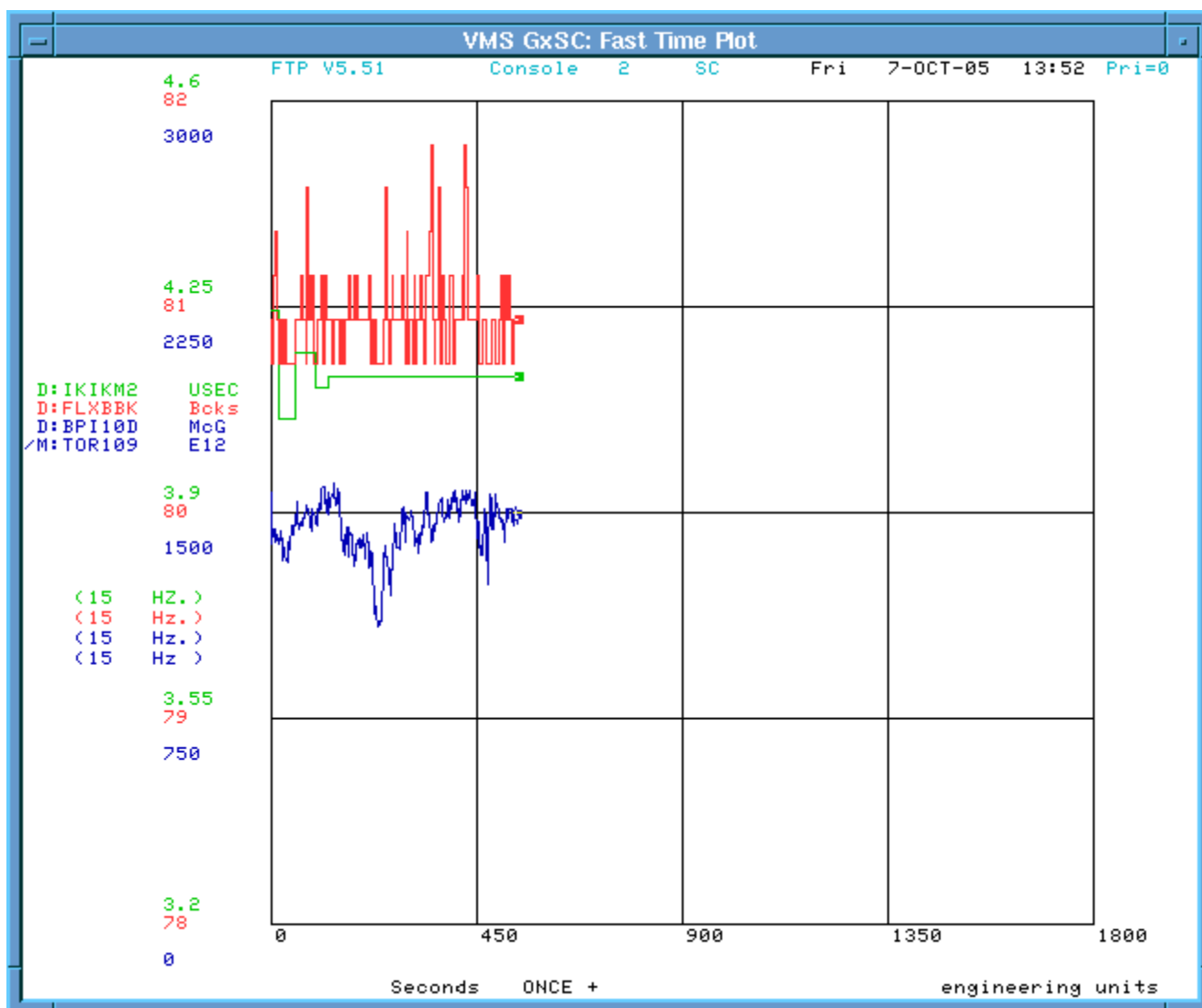


Figure 12: Pbar FTP #87 shows how our tuning efforts impact the number of bunches injected into the Debuncher (D:FLXBBK), the calculated Debuncher injection flux (D:INJFLX), the circulating Debuncher beam normalized to beam on target (D:BPI10D/M:TOR109).

- Also pay attention to the Flux Capacitor scope. This scope can be viewed from CATV Pbar #18 as shown in [Figure 13](#), or online at <http://ap10-flux-scope.fnal.gov/> as shown in [Figure 5](#).



Figure 13: Flux Capacitor Scope: The trace to the left is before a tune-up and the trace to the right is after a tune-up. Look closely at the left edge of the injected beam. The trace on the left plot shows less of a square wave than the same trace on the right plot.

4. All of the OAC generated Acnet Parameters and the Debuncher Injection kicker timing parameters are located on P60 BOSTR <36>, as shown in [Figure 14](#). The Java Application has a restore kicker timing feature; however, it is still recommended to have this page open.

VMS PA:P60 POWER SUPPLY PARAM									
P60	OPS KICKER TIMING TUNING	SET	D/A	A/D	Com-U	PTools			
-<FTP>+ *SA* X-A/D X=TIME Y=B:BLM026,Z:P DTMP,A:E T3HN,A:EM 3VN									
COMMAND ----- Eng-U I= 0 I= 0 0 0 0									
-<36>+ rSUP AUTO F= 180 F= 8 20 2 2									
acc10	acc30	acc50	deb10	deb30	deb50	protn	inj	dtoa	ext BOSTR
-D:SA11T Trigger for D:SB11SA 1.03 1.03 secs ...-									
! SET TO 1.03 FOR BUNCH ROTATION									
-D:IKIKM1 DEB INJ KICKER MAIN C 4.585 4.585 USEC ..									
! KICKER TUNING									
! >1.51 FOR STACKING									
-D:FLXBTL Deb Inj Flx Bnch Tr 1.52 1.524 * 1.524 uSec									
-D:FLXGAP Deb Inj Flux Gap Le 176 180 * 180 nSec									
! SHOULD BE 81 BUCKETS IN TRAIN									
-D:FLXBBK Deb Inj Flux BTL Bu 80.72 80.93 * 80.93 Bcks									
! SHOULD BE 9 BUCKETS IN GAP									
-D:FLXGBK Deb Inj Flux Gap Bu 9.347 9.559 9.559 Bcks									
MULT :3 D:IKIK TIMING									
-D:IKIKM1*.05 DEB INJ KICKER MAIN C 4.585 4.585 USEC ..									
-D:IKIKM2*.05 DEB INJ KICKER MAIN C 4.243 4.243 USEC ..									
-D:IKIKM3*.05 DEB INJ KICKER MAIN C 4.426 4.426 USEC ..									

Figure 14: P60 BOSTR <36> has all of the parameters that we need to complete the Debuncher Injection Kicker timer tune-up.

- From the Java Kicker Timer Program application, go to "KickerSelect" -> "DebuncherInjection" as shown in [Figure 15](#).

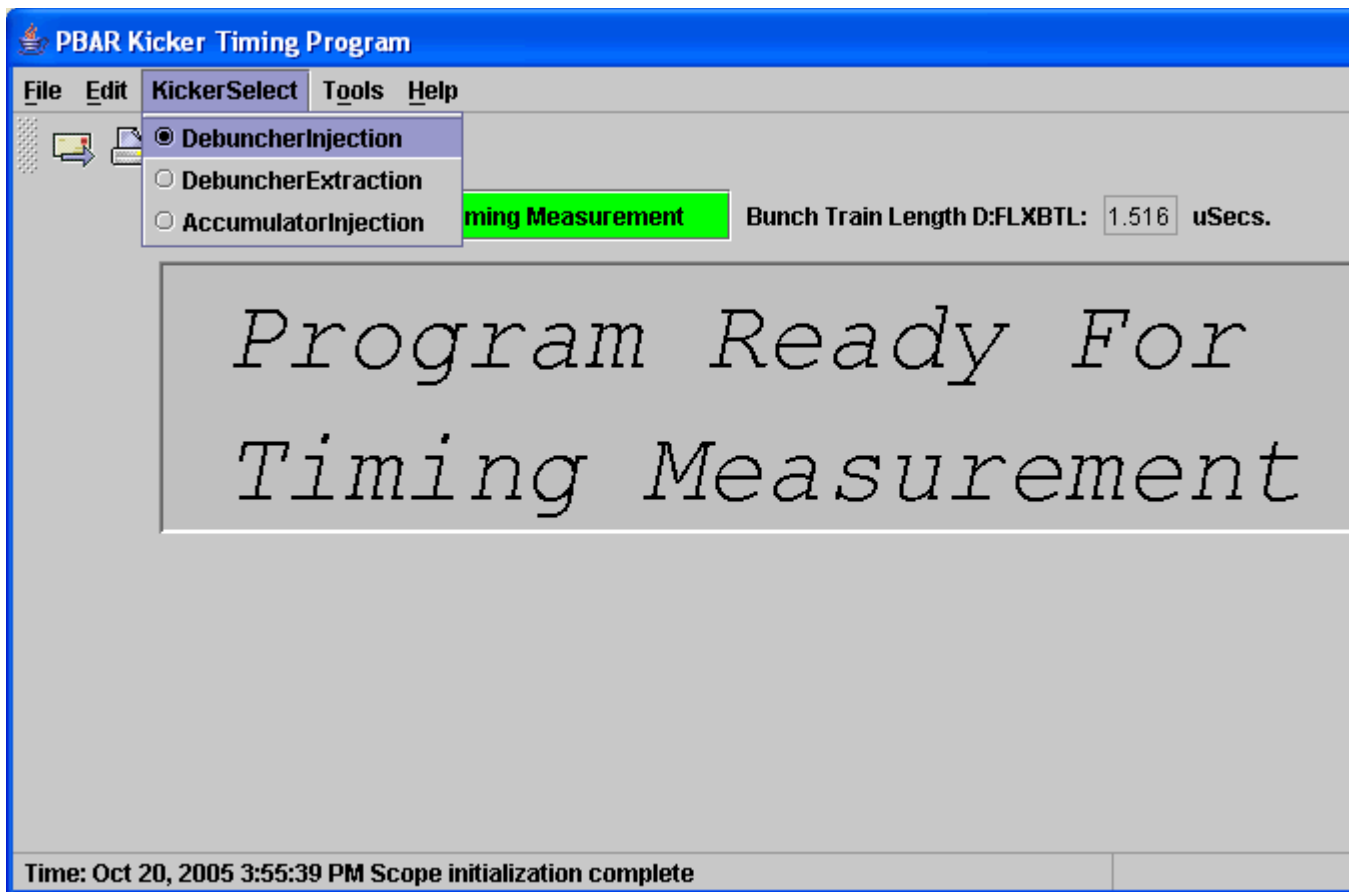


Figure 15: The Java Pbar Kicker Timing Program. Click on "KickerSelect" and then select "DebuncherInjection"

6. Click on the green box that is labeled "Begin Kicker Timing Measurement" as shown in [Figure 16](#). Note the value of D:FLXBTL.

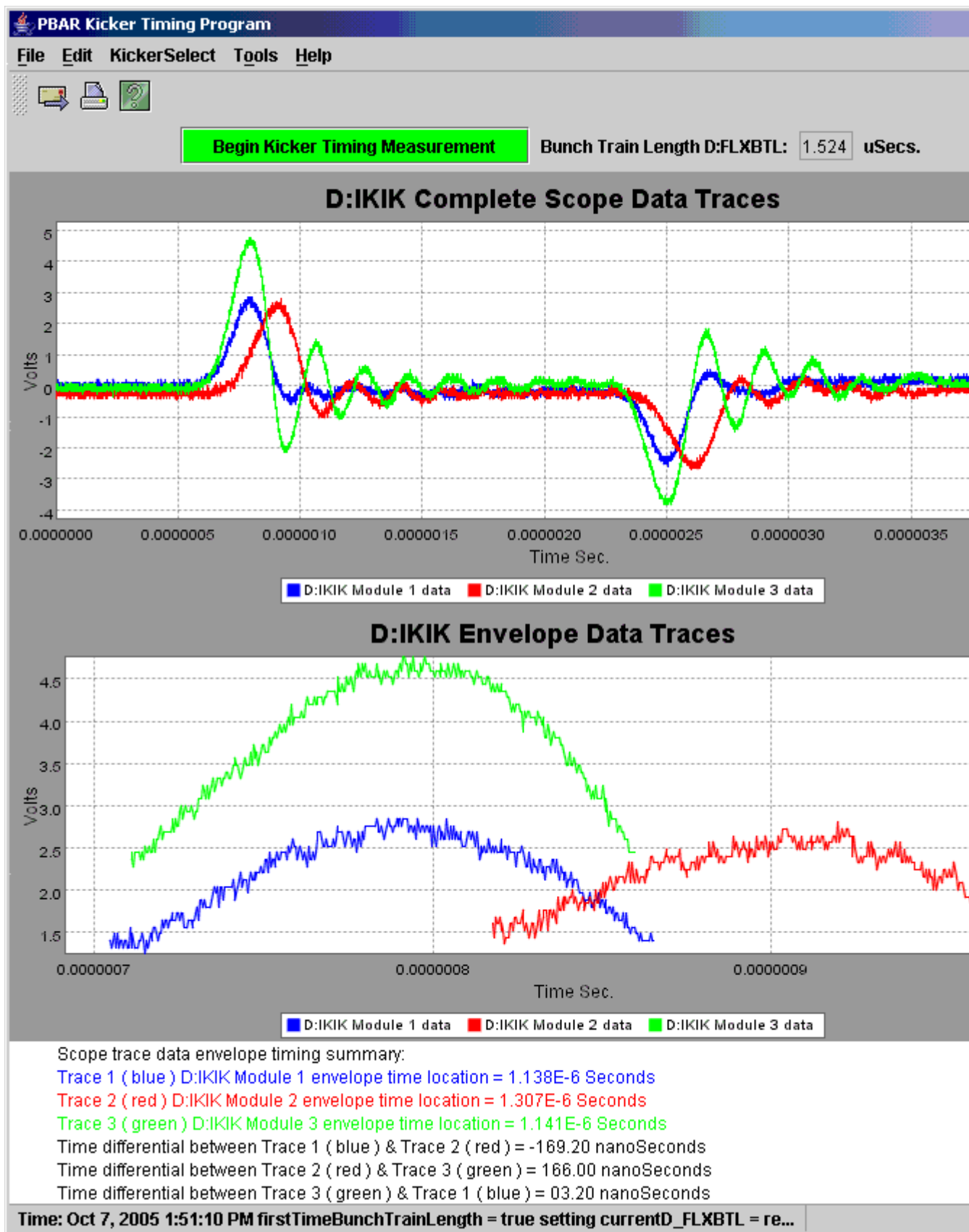


Figure 16: The Pbar Kicker Timing Program shows the

Debuncher Injection Kicker scope traces. The top plot is a reproduction of the kicker scope as viewed in [Figure 4](#). The bottom plot zooms in on the kicker scope peaks. In this example, it should be clear that the red trace (module 2) is not aligned with the other two traces.

7. If any tuning changes are required, you will get a popup window, as shown in [Figure 17](#), that states that D:IKIK has timing module differences that exceed 20 nanoseconds. If all of the kicker times are within 20 nanoseconds, you will get a popup window like that shown in [Figure 20](#), and can then skip ahead to [Step 11](#) of this procedure.

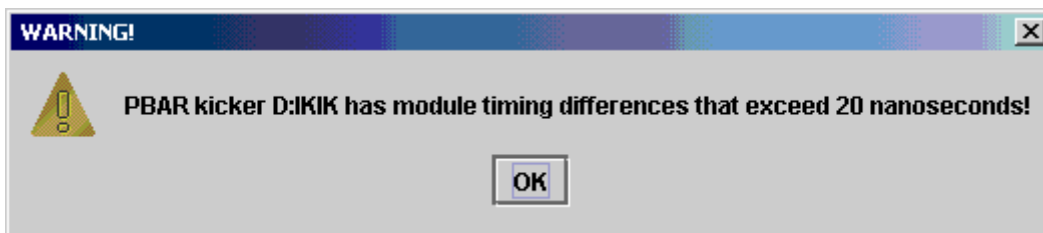


Figure 17: If one or more kickers need a timing change, then this popup window will appear. Click OK to view the results.

8. The Timing Results window (see [Figure 18](#)) presents the results and suggested tuning options. If the changes look reasonable, then make the suggested changes. It is normal to make ~200nsec changes.

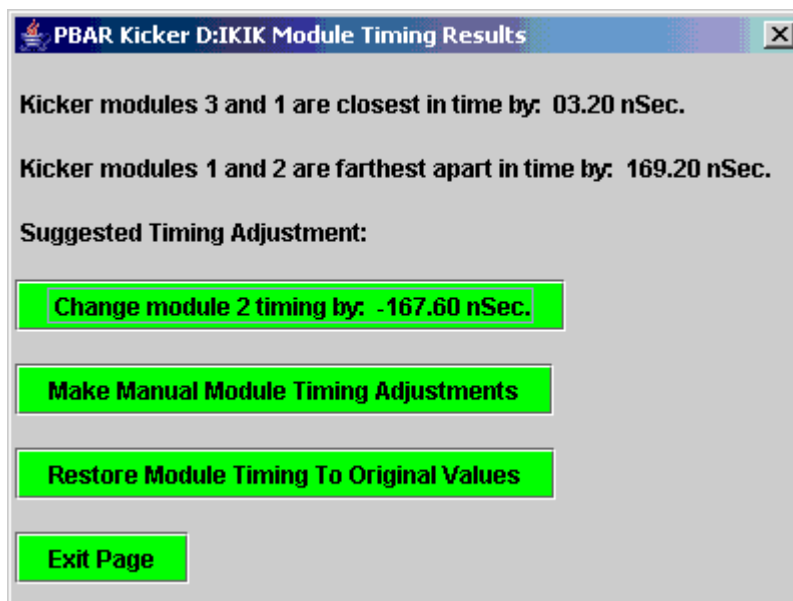


Figure 18: The results and suggested timing change are displayed on another popup window.

9. Examine the Pbar Kicker Timing application (see [Figure 19](#)) to see if the kicker trace alignment is converging. The value of D:FLXBTL should be the same or larger than that seen in [Step 6](#). Click on the green box that is labeled "Begin Kicker Timing Measurement" as shown in [Figure 19](#).

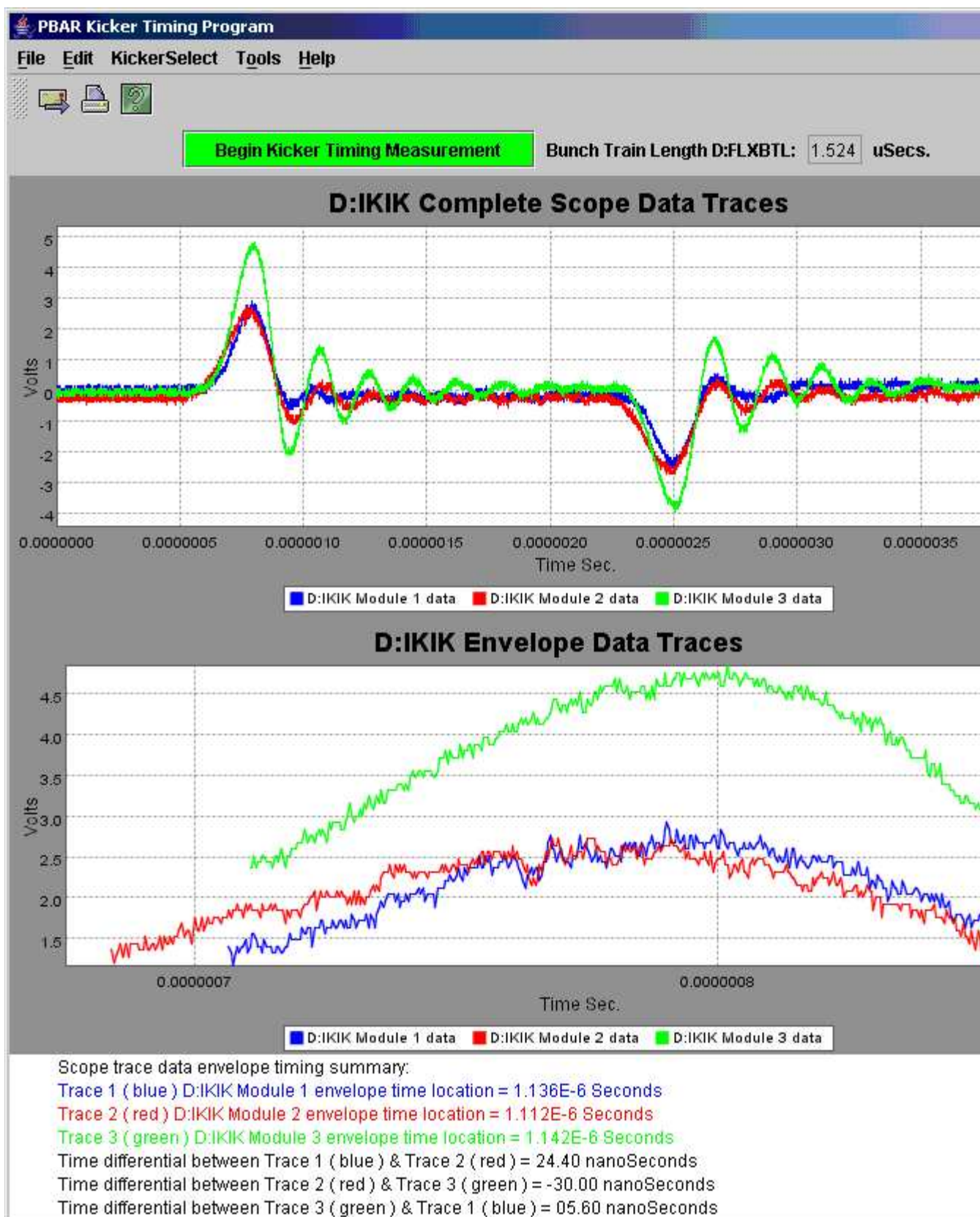


Figure 19: The Pbar Kicker Timing Program shows the Debuncher Injection Kicker scope traces. Comparing the

results of this display with that of [Figure 16](#), it is clear that the three traces are closer to being aligned after the tuning was completed.

10. Repeat [Step 6](#) to [Step 9](#) as necessary until all the kicker modules are aligned. Once aligned, a popup window will appear, as shown in [Figure 20](#), that says that all kicker modules are within 20 nanoseconds.

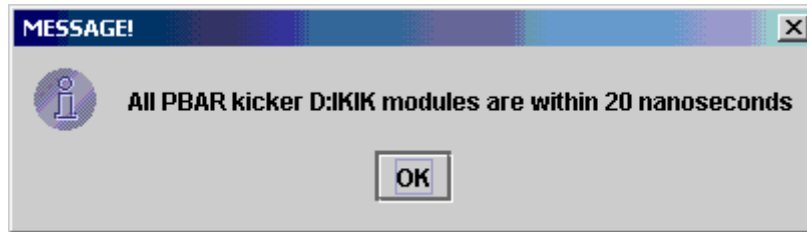


Figure 20: If all kicker modules are aligned within 20 nanoseconds then this popup window will appear. Simply click "OK" to continue.

11. In the next three steps, we will verify that the kicker traces are optimally aligned with the DRF2 gap.
12. As shown in [Figure 21](#) start a FTP from Utility Window FTP Pbar File 104.

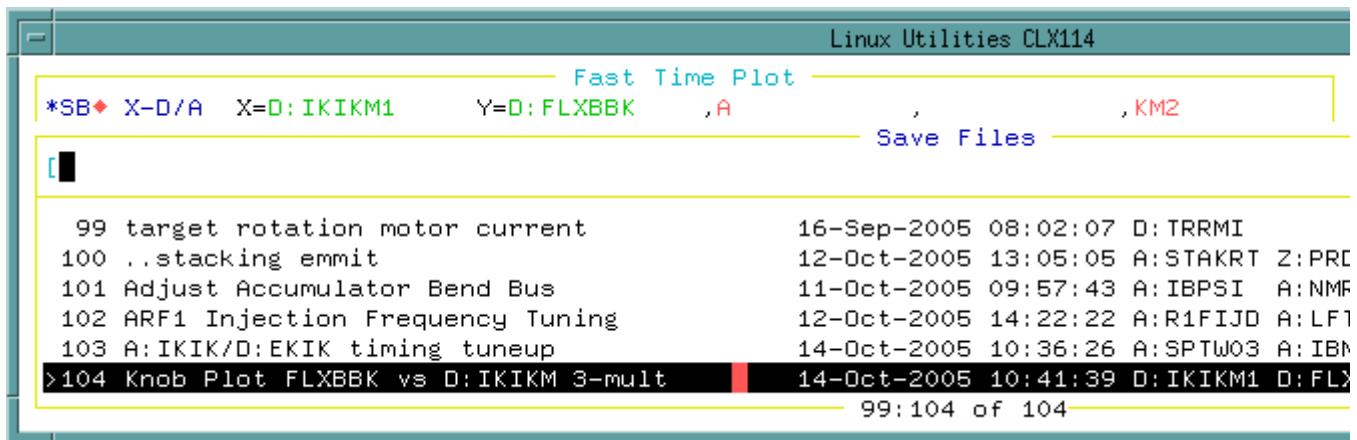


Figure 21: From the Utilities Window, click on FTP, then click on Restore, and then select P-bar. Select file 104 and start the FTP.

13. Pbar FTP 104 (see [Figure 22](#)) shows how the equivalent number of bunches injected into the Debuncher (D:FLXBBK) is impacted by Debuncher Injection Kicker timing.

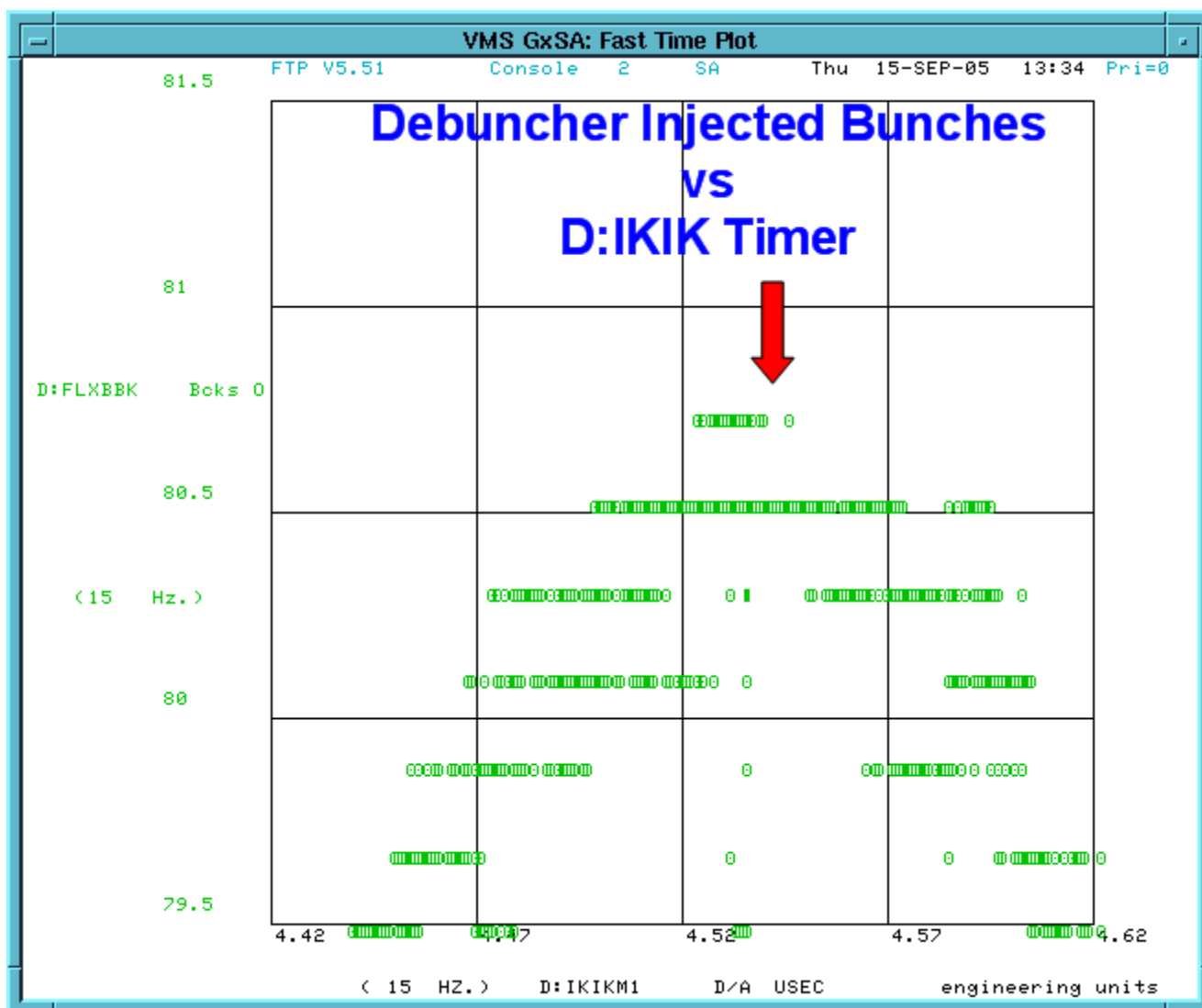


Figure 22: Tuning the Debuncher Injection kicker timer MULT:3 as found on P60 BOSTR <36> to maximize the value of D:FLXBBK. The red arrow represents the peak of the distribution.

14. Knob the Debuncher Injection Kicker timing MULT:3 from P60 BOSTR <36> (as shown in [Figure 14](#)) to maximize the value of D:FLXBBK. Under normal operating conditions, the parameter peaks at around 80.5 buckets.
15. Document any tuning changes in the [Pbar electronic log book](#).

Full Length Procedure - Part 3: Debuncher Extraction & Accumulator Injection Kicker Tuning (**Pbar Experts Only**).

This portion of the procedure shows how to tune-up the Debuncher Extraction and Accumulator Injection kicker timers. Due to lack of diagnostics, this portion of the procedure is intended for Pbar experts only.

1. As shown in Figure 23, start a FTP from Utility Window FTP Pbar File 104.

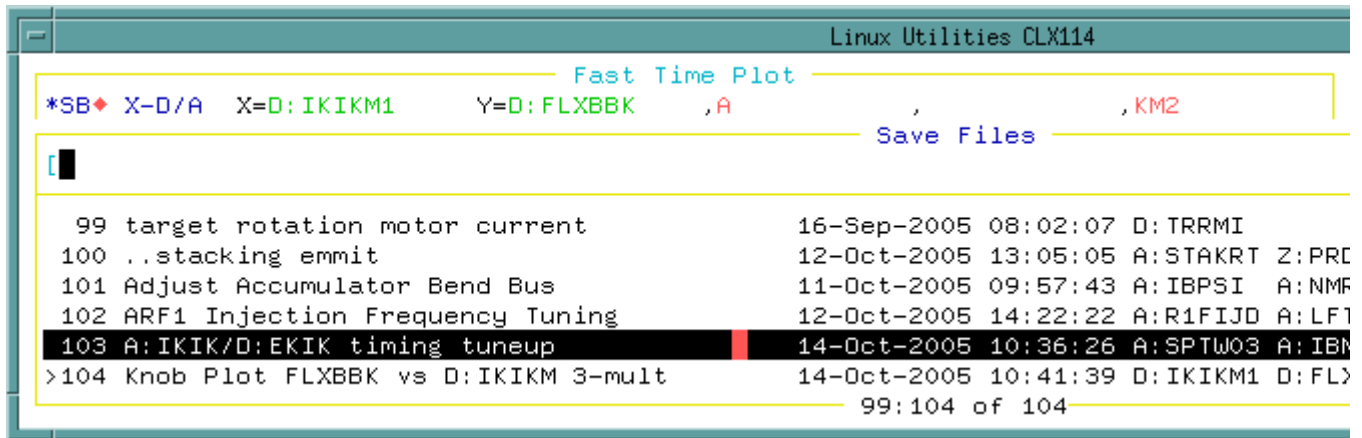


Figure 23: From the Utilities Window, click on FTP, then click on Restore, and then select P-bar. Select file 103 and start the FTP.

2. Pbar FTP 104 (see [Figure 24](#)) shows one Debuncher Extraction kicker module timer (D:EKIKM1), one Accumulator Injection kicker module timer (A:IKIKM1), the amount of beam injected in the accumulator (A:IBMINJ) in units of 1×10^7 as calculated from the stacking monitor, and the power in one of the stacktail TWTs (A:SPTW03). If our tuning efforts increase the beam to the Accumulator, then value of injected accumulator beam and stacktail power should both increase.

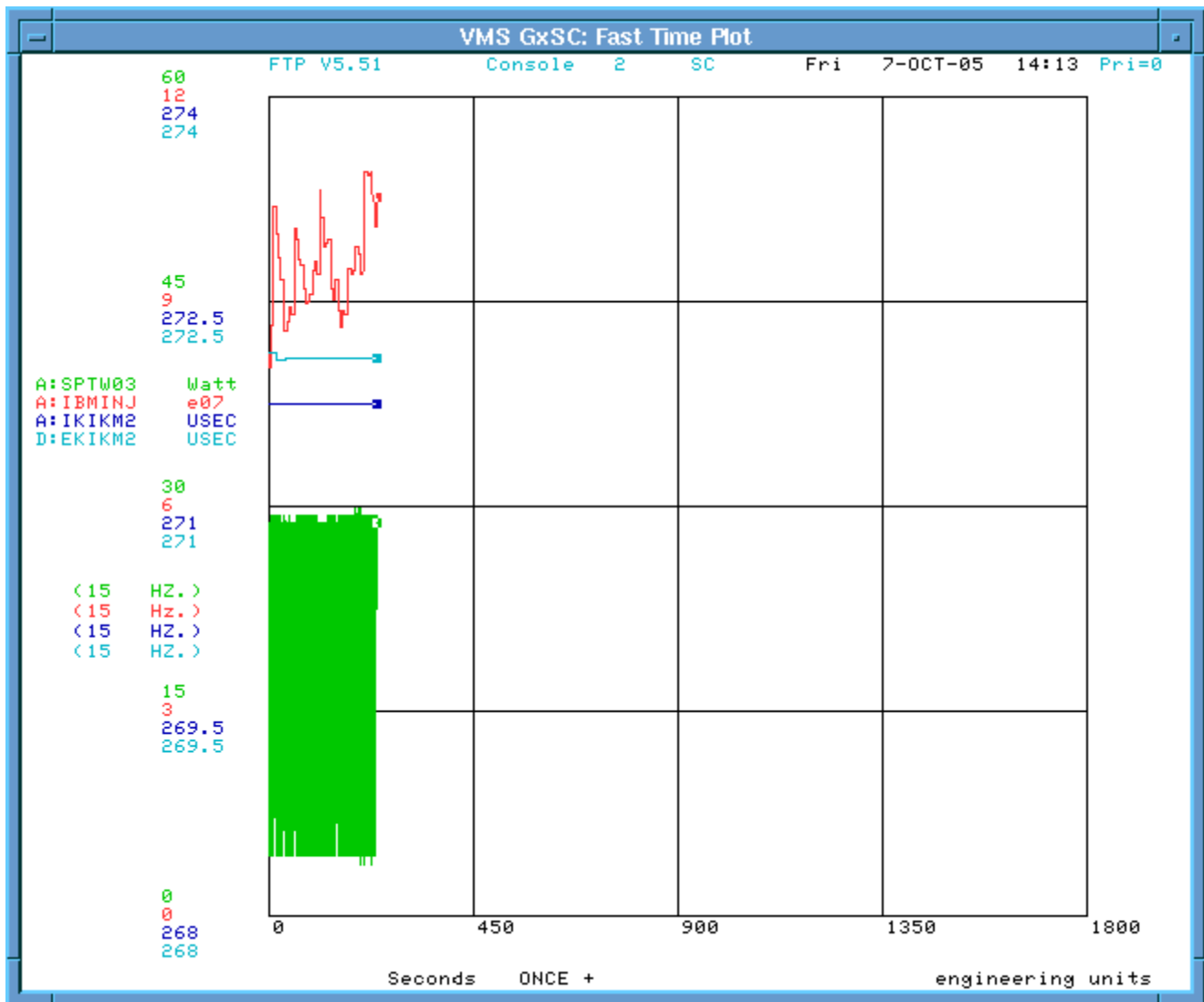


Figure 24: Pbar plot 103 shows one Debuncher Extraction kicker module timer (D:EKIKM1), one Accumulator Injection kicker module timer (A:IKIKM1), the amount of beam injected in the accumulator (A:IBMINJ) in units of 1×10^7 as calculated from the stacking monitor, and the power in one of the stacktail TWTs (A:SPTW03). If our tuning efforts increase the beam to the Accumulator, then value of injected accumulator beam and stacktail power should both increase.

3. Open P60 DTOA < 3> as shown in [Figure 25](#). This page contains two MULT:3s and one MULT:6 that we will use later in this procedure.

VMS PB:P60 POWER SUPPLY PARAM									
P60 D/A KICKER TIMING SET D/A A/D Com-U ♦PTools♦									
-<FTP>+ *SA* X-A/D X=TIME Y=B:BLM026,Z:P DTMP,A:E T3HN,A:EM 3VN									
COMMAND ----- Eng-U I= 0 I= 0 0 0 0									
-< 3>+ rSUP AUTO F= 180 F= 8 20 2 2									
acc10 acc30 acc50 deb10 deb30 deb50 protn inj DTOA ext bostr									
!D:EXTRAC SHOULD BE ON INPUT A FOR STACKING									
-D:R2LLAM DRF2 LLRF AMPLITUDE 6.27 6.305 VOLT .									
D:EXTRAC D TO A TRANSFER CONTROL AH									
D:R2HLSC DRF2 Hi Lvl Stat/Cntrl .									
MULT :6									
-D:EKIKM1*.01 DEB EXT KICKER MAIN C 272.351 272.351 USEC ..									
-D:EKIKM2*.01 DEB EXT KI 272.117 272.083 272.083 USEC ..									
-D:EKIKM3*.01 DEB EXT KICKER MAIN C 272.503 272.503 USEC ..									
-A:IKIKM1*.01 ACC IN KIC 271.737 271.721 USEC ..									
-A:IKIKM2*.01 ACC IN KICKER MAIN CH 271.75 271.75 USEC ..									
-A:IKIKM3*.01 ACC IN KIC 271.601 271.572 271.572 USEC ..									
-A:IKIKP A:IKIK F.P.FACTOR 51.5 -.123 KV ...									
MULT :3									
-A:IKIKM1*.01 ACC IN KIC 271.737 271.721 271.721 USEC ..									
-A:IKIKM2*.01 ACC IN KICKER MAIN CH 271.75 271.75 USEC ..									
-A:IKIKM3*.01 ACC IN KIC 271.601 271.572 271.572 USEC ..									
D:R2HLFB DRF2 Fanback Voltage 199.2 Volt									
D:R2HLSC DRF2 Hi Lvl Stat/Cntrl .									
MULT :3 D:EKIK TIMING									
-D:EKIKM1*.1 DEB EXT KICKER MAIN C 272.351 272.351 USEC ..									
-D:EKIKM2*.1 DEB EXT KI 272.117 272.083 272.083 USEC ..									
-D:EKIKM3*.1 DEB EXT KICKER MAIN C 272.503 272.503 USEC ..									
-D:SA13T Trigger for D:SB13SA .2 .2 secs ..									
A:STCKRT Pbar Stacking Rate 10 mA/h									
A:PRDCTN PBARS PER P @ TOR109 11.61 E-6									
Z:PRDTMP PBARS PER P @ TOR109 11.68 E-6									
-D:EKIKEC DEB-EKIK error count 657252 657252 cnt									
-A:IKIKEC ACC-IKIK error count 34583 34583 cnt									

Figure 25: P50 DTOA < 3> contains the Debuncher Extraction Kicker timing and Accumulator Injection kicker timing MULTs. The Debuncher Extraction kicker MULT:3 can be used to align the Debuncher Extraction kicker with the DRF2 gap. The Accumulator Injection kicker MULT:6 can be used to align the Accumulator Injection kicker timing with the Debuncher Extraction kicker timing. The Accumulator Injection and Debuncher Extraction kicker timer MULT:6 can be used to align all the kickers with the DRF2 gap.

4. From the Java Kicker Timer Program application, go to "KickerSelect" ->

"DebuncherExtraction" as shown in [Figure 26](#).

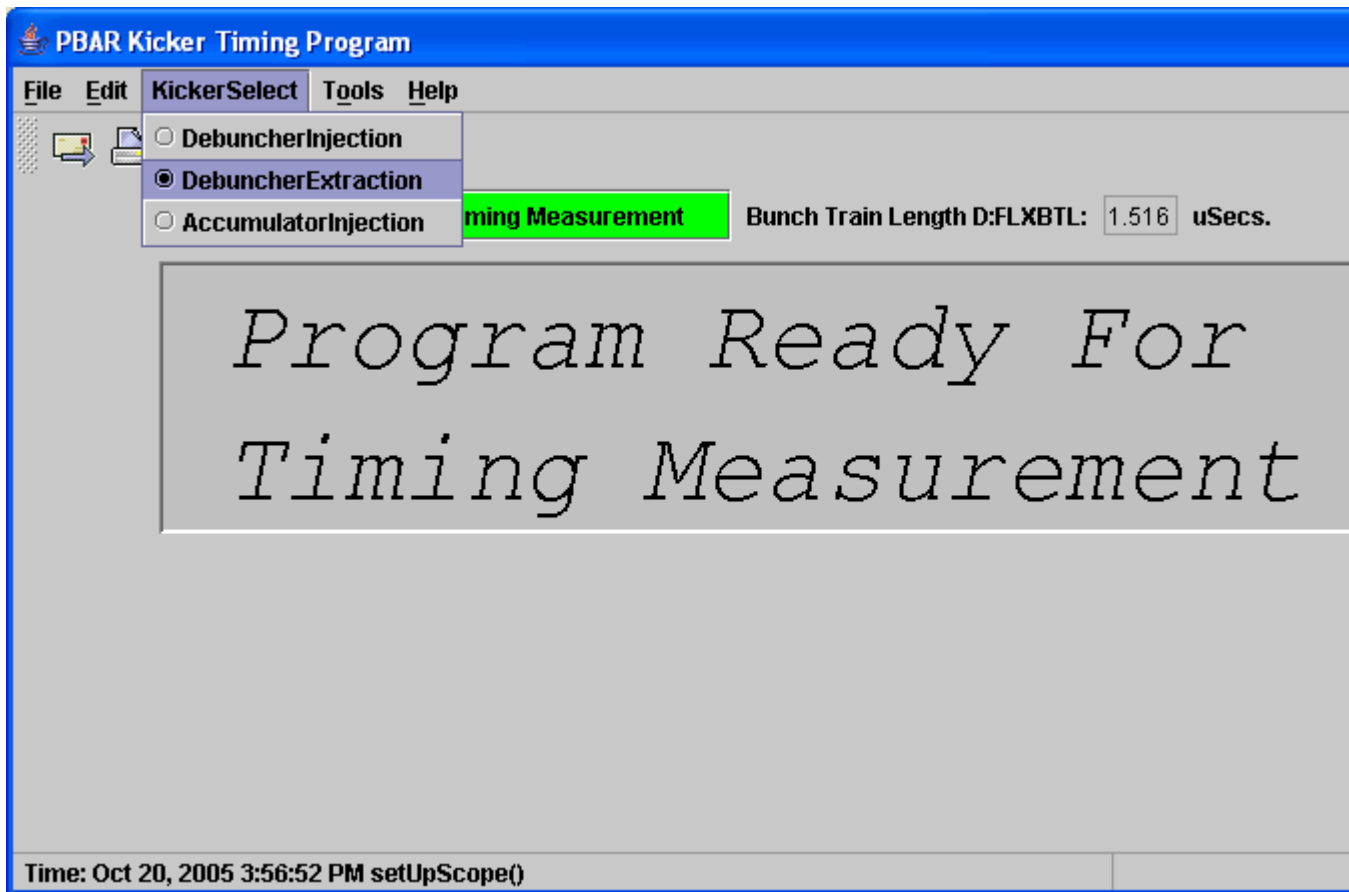


Figure 26: The Java Pbar Kicker Timing Program. Click on "KickerSelect" and then select "DebuncherExtraction"

5. Click on the green box that is labeled "Begin Kicker Timing Measurement" as shown in [Figure 27](#). D:FLXBTL is used for Debuncher injection and can be ignored in this portion of the procedure.

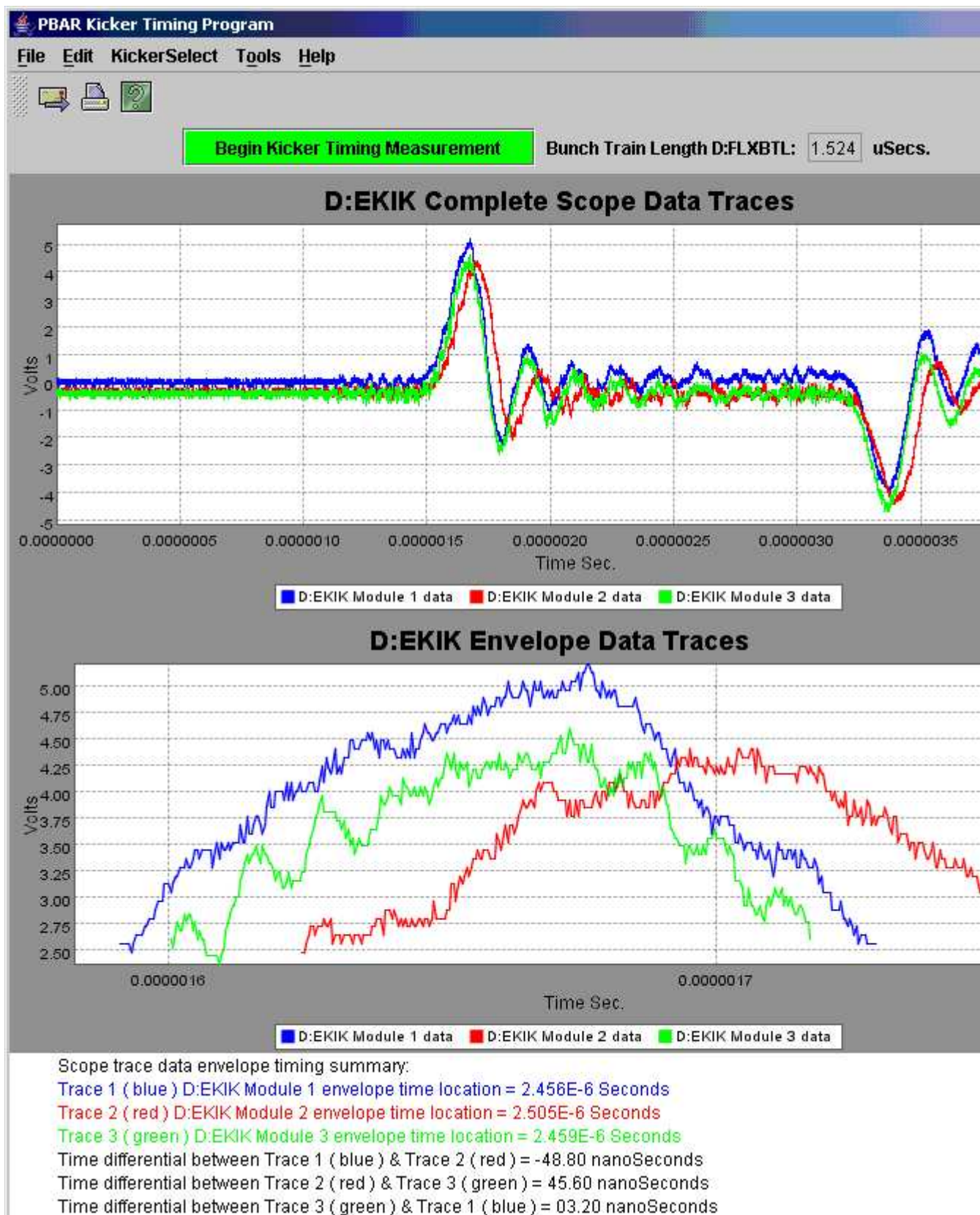


Figure 27: The Pbar Kicker Timing Program shows the Debuncher Extraction Kicker scope traces. The top plot is a

reproduction of the kicker scope as viewed in [Figure 7](#). The bottom plot zooms in on the kicker scope peaks. In this example, it should be clear that the red trace (module 2) is not aligned with the other two traces.

6. If any tuning changes are required, you will get a popup window, as shown in [Figure 28](#), that states that D:EKIK has timing module differences that exceed 20 nanoseconds. If all of the kicker times are within 20 nanoseconds then skip ahead to [Step 10](#) of this procedure.

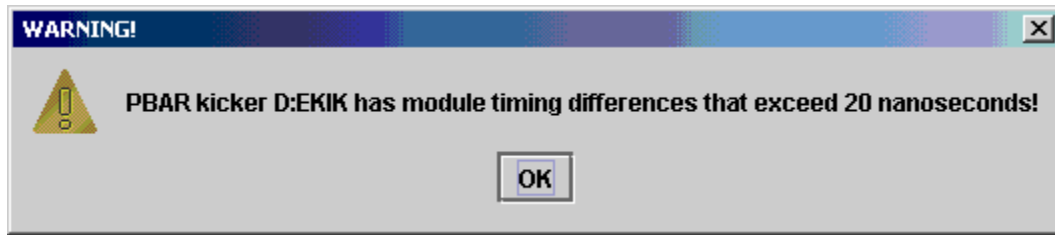


Figure 28: If one or more kickers need a timing change, then this popup window will appear. Click OK to view the results.

7. The Timing Results window (see [Figure 29](#)) presents the results and suggested tuning options. If the changes look reasonable, then make the suggested changes. It is normal to make ~200nsec changes.

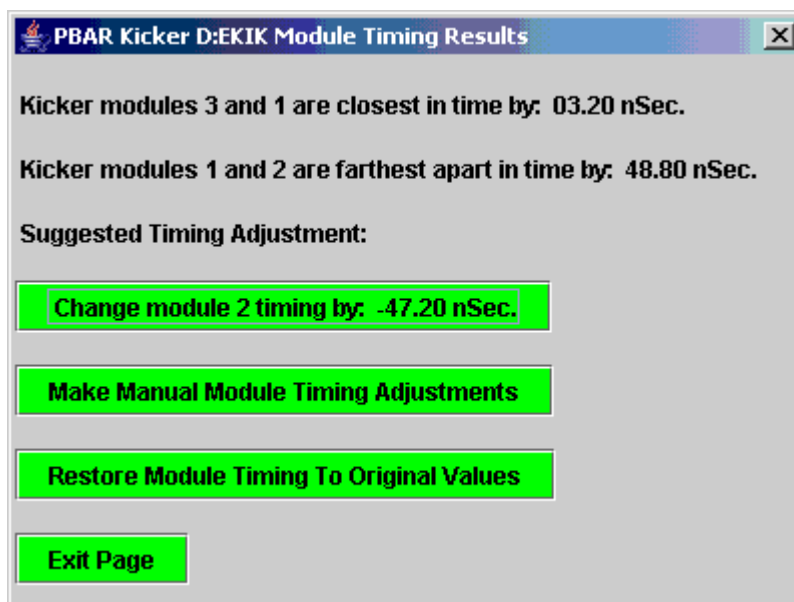


Figure 29: The results and suggested timing change are displayed on another popup window.

8. Examine the Pbar Kicker Timing application (see [Figure 30](#)) to see if the kicker trace alignment is converging. Click on the green box that is labeled "Begin

Kicker Timing Measurement."

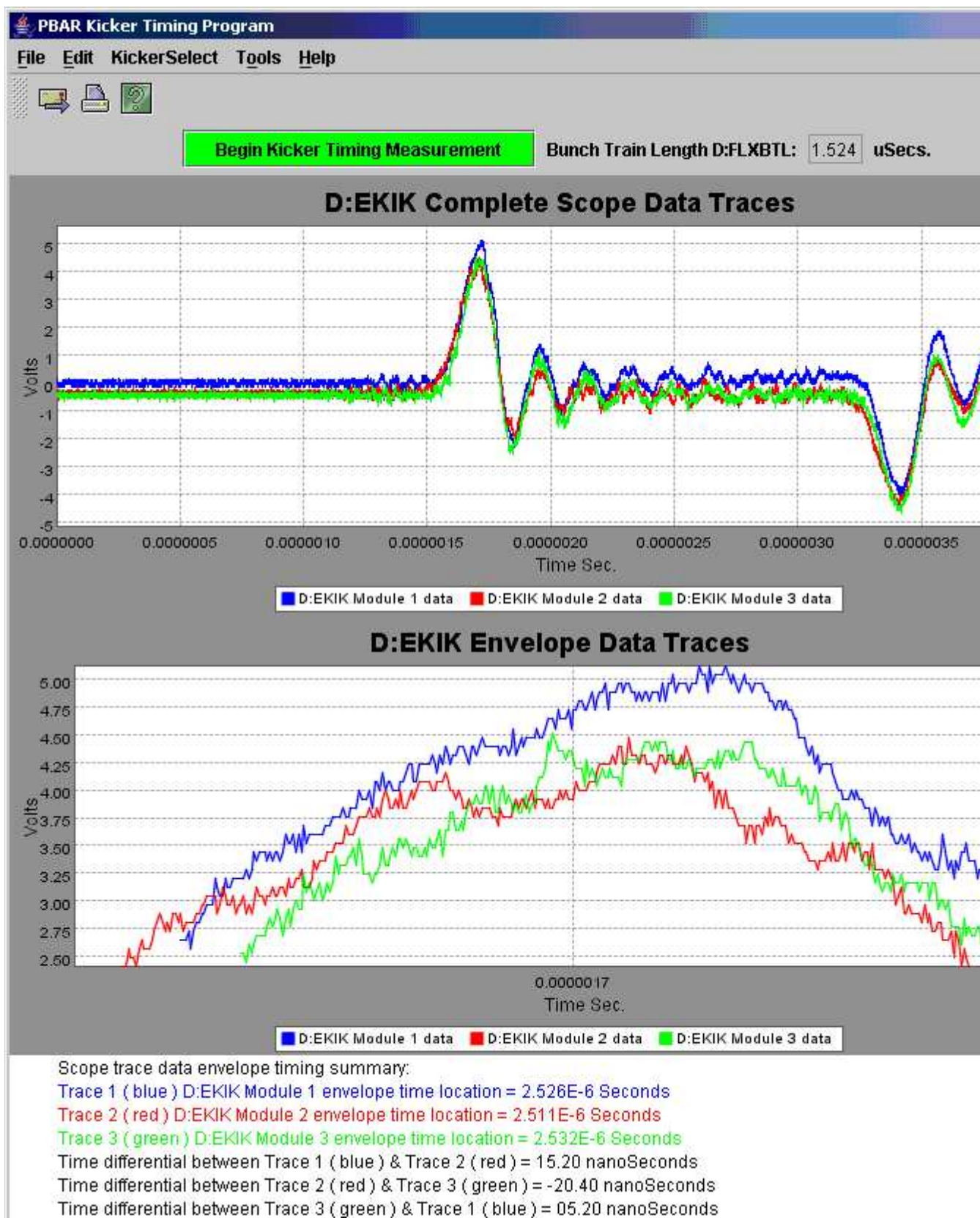


Figure 30: The Pbar Kicker Timing Program shows the Debuncher Extraction Kicker scope traces. Comparing the results of this display with that of [Figure 27](#), it is clear that the three traces are closer to being aligned after the tuning was completed.

9. Repeat [Step 5](#) through [Step 8](#) until the kicker traces are aligned within 20 nanoseconds.
10. From P60 DTOA < 3>, as shown in [Figure 25](#), slowly knob the D:EKIKM% (% = 1, 2, or 3) MULT:3 to optimize the kicker with respect to the DRF2 gap. Watch the FTP as well as stackrate and production.
11. From the Java Kicker Timer Program application, go "KickerSelect" -> "AccumulatorInjection" as shown in [Figure 31](#).

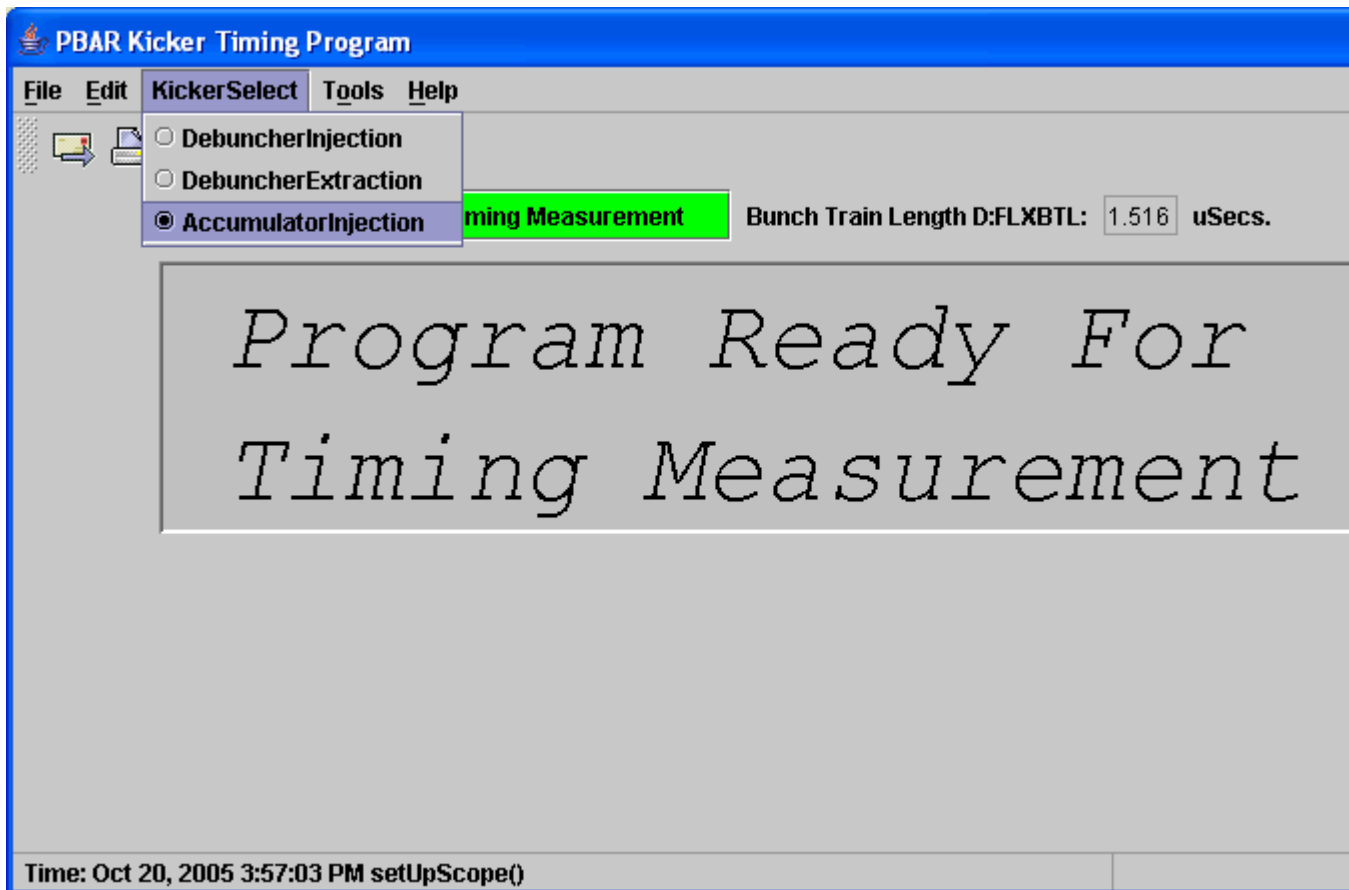


Figure 31: The Java Pbar Kicker Timing Program. Click on "KickerSelect" and then select "Accumulator Injection"

12. Click on the green box that is labeled "Begin Kicker Timing Measurement" as shown in [Figure 32](#). D:FLXBTL is used for Debuncher injection and can be

ignored in this portion of the procedure.

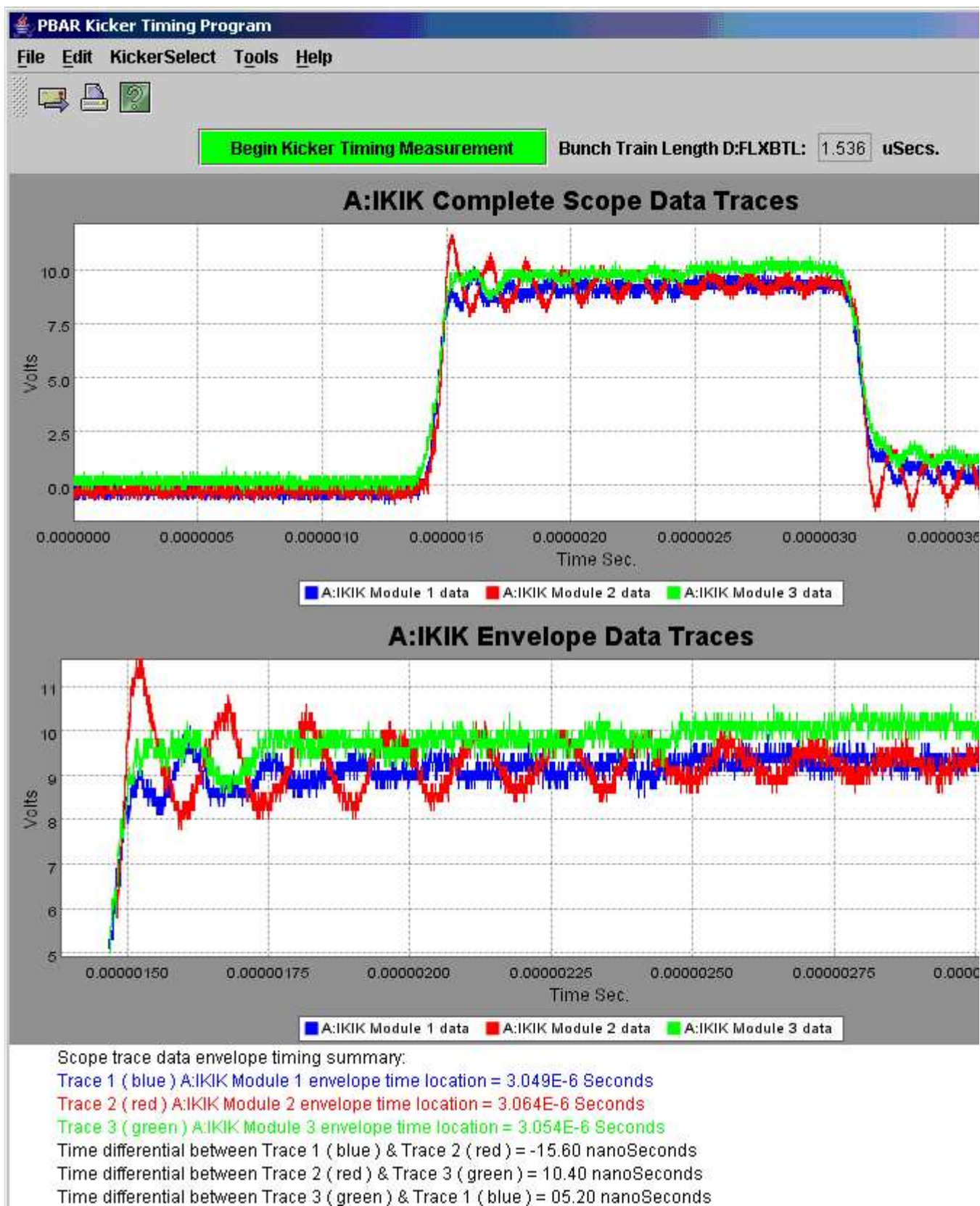


Figure 32: The Pbar Kicker Timing Program shows the Accumulator Injection Kicker scope traces. The top plot is a reproduction of the kicker scope as viewed in [Figure 9](#). The bottom plot zooms in on the kicker scope traces.

13. If any tuning changes are required, you will get a popup window, as shown in [Figure 33](#), that states that A:IKIK has timing module differences that exceed 20 nanoseconds. If all of the kicker times are within 20 nanoseconds then skip ahead to [Step 17](#) of this procedure.

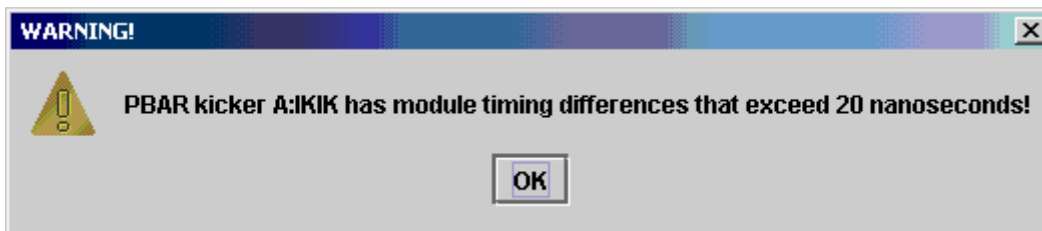


Figure 33: If one or more kickers need a timing change, then this popup window will appear. Click OK to view the results.

14. The Timing Results window (see [Figure 34](#)) presents the results and suggested tuning options. If the changes look reasonable, then make the suggested changes. It is normal to make ~200nsec changes.

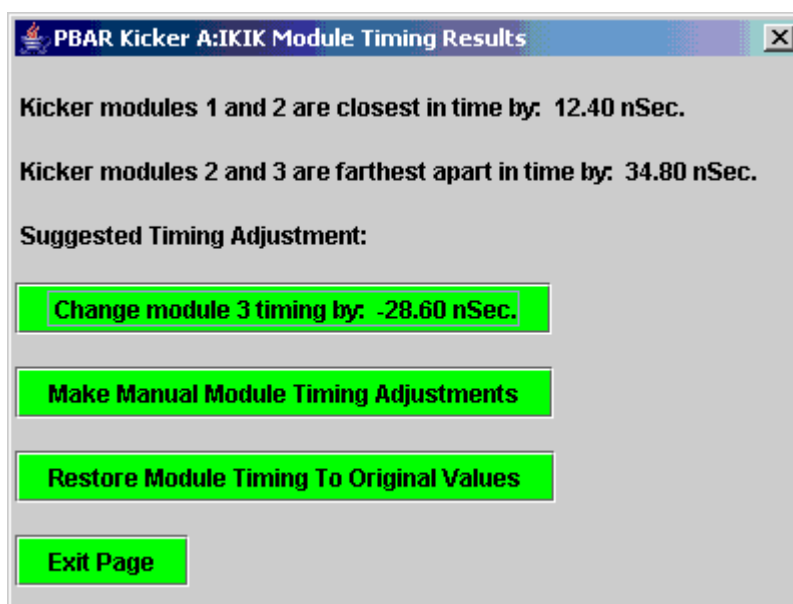


Figure 34: The results and suggested timing change are displayed on another popup window.

15. Examine the Pbar Kicker Timing application (see [Figure 35](#)) to see if the kicker trace alignment is converging. Click on the green box that is labeled "Begin

Kicker Timing Measurement."

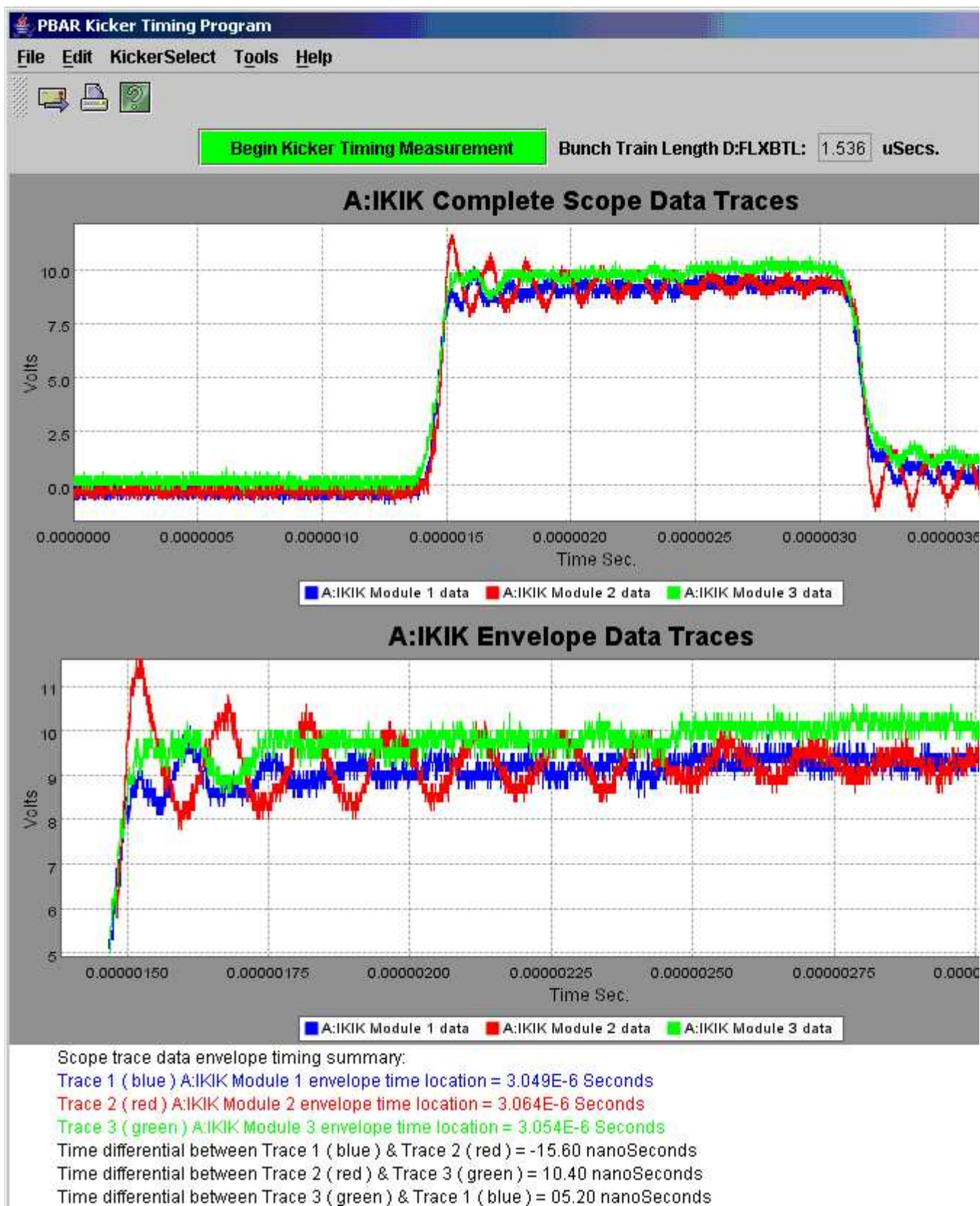


Figure 35: The Pbar Kicker Timing Program shows the Debuncher Extraction Kicker scope traces.

16. Repeat [Step 12](#) through [Step 15](#) until the kicker traces are aligned within 20 nanoseconds as shown in [Figure 36](#).

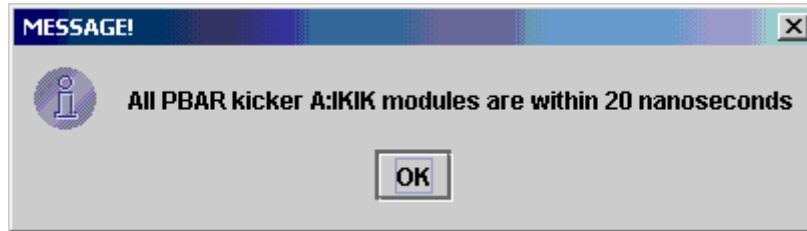


Figure 36: If all kicker modules are aligned within 20 nanoseconds then this popup window will appear. Simply click "OK" to continue.

17. From P60 DTOA < 3>, as shown in [Figure 25](#), slowly knob the A:IKIKM% (% = 1, 2, or 3) MULT:3 to optimize the A:IKIK kicker with respect to the D:EKIK kicker timing. Watch the FTP as well as stackrate and production.
18. From P60 DTOA < 3>, as shown in [Figure 25](#), slowly knob the D:EKIKM% (% = 1, 2, or 3) + A:IKIKM% (% = 1, 2, or 3) MULT:6 to optimize both kickers in respect to the DRF2 gap. Watch the FTP as well as stackrate and production.
19. When in doubt, put your changes back.
20. Document any tuning changes in the [Pbar electronic log book](#).

Condensed Procedure:

The following is a condensed checklist of the steps covered in the above procedure. No screen captures nor motivating discussion are provided in this section. For more detail, discussion and screen captures, read the [Full Length Procedure](#) above.

1. **Start the Java Kicker Timing Application**
 - a. The Java application can be started by clicking on the following link: <http://www-bd.fnal.gov/appix/start?p=40000142&n=35000508>. The application can also be started from the [Java Index](#). One open, click on

"Launch in Application Browser." The Application Index window appears. Open the P * Pbar folder and double click on "Pbar Kicker Timing."

- b. Once the application is open, we can complete either of the following two procedures.
 - a. **D:IKIK timer tuning (Ops and Experts)**
 - b. **D:EKIK & A:IKIK timer tuning (Experts only)**

D:IKIK Timer Tuning (Ops and Experts)

1. Tuning D:IKIK timers (Ops and Experts)

- a. Start Utilities Windows FTP Pbar plot #87
- b. Click on "KickerSelect" in the menu bar and select "Debuncher Injection Kicker."
- c. Click on "Begin Kicker Timing Measurement."
- d. A pop-up window will appear:
 - i. If the popup window states that all kickers are within the 20nsec tolerance, then click ok and skip to step 1.g
 - ii. If the popup window states that there is at least one kicker more than 20nsec out of tolerance, click ok and continue to step 2.f
- e. Another popup window appears showing the timing results. Click to make the recommended changes.
- f. Repeat steps 1.c-1.e above until all kicker traces are aligned.
- g. If D:FLXBBK < 80 buckets, or if D:FLXBBK decreased after tuning, then go to step 2.

2. Verifying D:IKIK mult is optimized.

- a. Start Utilities Windows FTP Pbar plot #104
- b. Knob the D:IKIKM 3-mult on page P60 Boost <36> to maximize D:FLXBBK, which should be greater than 80.5 buckets.

3. If D:FLXBBK is still < 80 buckets, start the Proton Torpedo SA from P194.

- a. If the Proton Torpedo shows less than injected 81 buckets, go back to your Booster and Main Injector tuning procedures to find what is wrong.
 - b. If the Proton Torpedo shows 81 injected buckets, then contact a Pbar on-call expert.
4. Document any tuning changes in the [Pbar electronic log book](#).
5. For a more detailed treatment of this procedure, please see the [Full Procedure](#).

D:EKIK & A:IKIK Timer Tuning (Experts Only)

1. **Tuning D:EKIK timers (expert only)**
 - a. Start Utilities Windows FTP Pbar plot #103
 - b. Go To P60 DtoA < 3>.
 - c. Click on "KickerSelect" in the menu bar and select "Debuncher Extraction Kicker."
 - d. Click on "Begin Kicker Timing Measurement."
 - e. A pop-up window will appear:
 - i. If the popup window states that all kickers are within the 20nsec tolerance, then click ok and skip to step 5.
 - ii. If the popup window states that there is at least one kicker more than 20nsec out of tolerance, click ok and continue to step 4.f
 - f. Another popup window appears showing the timing results. Click to make the recommended changes.
 - g. Repeat steps 4.c-4.f above until all kicker traces are aligned.
2. **Tuning A:IKIK timers (expert only)**
 - a. Start Utilities Windows FTP Pbar plot #103
 - b. Go To P60 DtoA < 3>
 - c. Click on "KickerSelect" in the menu bar and select "Accumulator Injection Kicker."

- d. Click on "Begin Kicker Timing Measurement."
 - e. A pop-up window will appear:
 - i. If the popup window states that all kickers are within the 20nsec tolerance, then click ok and skip to step 6.
 - ii. If the popup window states that there is at least one kicker more than 20nsec out of tolerance, click ok and continue to step 5.f
 - f. Another popup window appears showing the timing results. Click to make the recommended changes.
 - g. Repeat steps 5.c-5.f above until all kicker traces are aligned.
 - h.
3. **Verifying D:EKIK & A:IKIK 3-Mults and 6-Mult (expert only)**
 - a. Start Utilities Windows FTP Pbar plot #103
 - b. Go To P60 DtoA < 3>.
 - c. Knob D:EKIK timer 3-mult to maximize Accumulator beam.
 - d. Knob A:IKIK timer 3-mult to maximize Accumulator beam.
 - e. Knob A:IKIK & D:EKIK timer 6-mult to maximize Accumulator beam.
 4. Document any tuning changes in the [Pbar electronic log book](#).
 5. For a more detailed treatment of this procedure, please see the [Full Procedure](#).
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